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Two New Races of *Natrix erythrogaster*

By ROGER CONANT

THE red-bellied water snake, *Natrix erythrogaster*, has had an erratic taxonomic history. Ever since 1771, when Forster assigned a binomial to the species (basing it upon Catesby's plate 46 [1731]), the name *erythrogaster* has been tossed about with considerable abandon, having been frequently applied to the wrong species or (more often) buried in synonymy. Only recently has it been generally accepted as the correct appellation for the large water snake of the southern and central lowlands that is characterized by a uniform dark dorsum and a uniform brightly colored abdomen, which may be red, orange, or yellow.

Hubert Lyman Clark, as long ago as 1903, clearly defined the characteristics of the snake, yet his work was ignored for years by many leading students of North American serpents. Even the authors of the check list dismissed *erythrogaster* with a terse footnote in their earlier editions and did not admit it to its rightful status until their fourth revision (Stejneger and Barbour, 1939).

There have been several reasons why the red-bellied water snake failed to achieve recognition. Chief among these was the fact that it was long confused with *Natrix sipedon* and several of its races. Numerous individuals of the *sipedon* formenkreis exhibit plain or nearly plain bellies, and I have encountered many of them wrongly identified in several of the museum collections I have examined. Likewise, actual specimens of *erythrogaster* have been catalogued under a variety of other names.

Another factor was due to the former prevalence of thinking in terms of the "old systematics"—i. e., attempting to assign a definite subspecific name to each individual specimen, even though it might belong to an intergrading population or be an isolated variant. This, combined with the widespread belief that water snakes are a difficult group, resulted in a poor understanding of the extent of variation within any one species. Even more important, perhaps, is the circumstance that the colors of many water snakes fade quickly in preservatives, the reds and yellows being particularly fleeting. And coloration and its distribution upon the body are of diagnostic importance. In this respect, it should be stressed that all descriptive matter below and all comments on coloration are based almost exclusively upon live specimens. Because of my association with a large zoological garden it has been possible to maintain considerable numbers of water snakes alive, a fact that has contributed enormously toward evaluating the status of the several races of *erythrogaster*.

Currently, most herpetologists recognize two subspecies: (1) a unicolored form from the eastern states—*erythrogaster*; and (2) a well-patterned race that ranges from Kansas to Texas and northern Mexico—*transversa*. I propose two additional subspecies herewith and restrict the name *erythrogaster* to the population occurring chiefly in the Coastal Plain Province from Maryland to northwestern Florida and eastern Alabama (type locality

herein designated as near Parker's Ferry, Edisto River Swamp, Charleston County, South Carolina—approximately 16 miles west of the city of Charleston).

The snakes of this species that inhabit the Mississippi Embayment and certain adjacent areas are characterized by yellow, instead of red, bellies. Several authors, including Viosca (1924) and Clay in his key to American *Natrix* (1938), have mentioned the fact. This race may be called

Natrix erythrogaster flavigaster, ssp. nov.

YELLOW-BELLIED WATER SNAKE

Plate I, fig. 3—a, b, c

TYPE.—No. 54001, Chicago Natural History Museum, an adult ♂ collected May 9, 1947, at Frenier Beach, St. John the Baptist Parish, Louisiana, by Dr. Fred R. Cagle and A. H. Chaney.

DIAGNOSIS.—A large water snake of the genus *Natrix* that is characterized by a more or less uniform grey or greenish grey dorsum and a plain (or nearly plain) yellow- or lemon-colored venter. From adults of the subspecies *erythrogaster* and *neglecta* it may be distinguished by its coloration; it differs from *transversa* in not (normally) retaining strong indications of the juvenile pattern throughout life. For details of color and pattern variations in the four races of *erythrogaster* see Table I.

All other snakes of the genus *Natrix* occurring within the range of *flavigaster* normally have strongly patterned abdomens; it stands alone (in the adult coloration) by exhibiting a plain, or nearly plain, under surface. Dark pigmentation upon the belly in *flavigaster*, if present, appears merely as an encroachment of the dorsal coloration upon the ends and bases of the ventral scutes; there are no well-defined spots, blotches, stripes, or other markings prominently in contrast with the ventral ground color. Attention should be called to the fact that some specimens of *Natrix grahamii* lack the mid-ventral black spots that usually characterize that species; such snakes may be identified, however, by the broad light lateral stripe and the narrow, sharply-defined black line (or row of black spots) along the common sutures of the ventrals and the scales of the first dorsal row.

Juveniles of *flavigaster* are virtually indistinguishable from juveniles of *erythrogaster* and *transversa*. But the possession of a combination of three characters will serve to separate them from the young of other *Natrix* occurring in the same area—(1) a pattern of large dark dorsal saddles flanked by an alternating row of smaller dark spots on each side of the body, (2) dark areas on the bases of the ventrals, these often being expanded to form a pair of small but bold dark markings on the base of each belly plate, and (3) paired light parietal spots plus a light postparietal streak or spot.

In both adults and juveniles of *flavigaster* the eye is proportionately large, its horizontal diameter being greater than, or at least almost as great as, the distance from the anterior edge of the orbit to the posterior border of the nostril. This characteristic is shared by the other races of *erythrogaster*.

DESCRIPTION OF THE TYPE.—Head shields normal for the genus; paired and bilaterally symmetrical internasals, prefrontals, supraoculars, and par-

ietals. Two nasals, the anterior somewhat the larger and containing the nostril. Loreal about as long as high. One preocular and three postoculars. One temporal in the first row and three in the second. Supralabials 8, the sixth and seventh the largest; the fourth and fifth enter the orbit. Infralabials 10, the sixth the largest and the first pair meeting on the chin posterior to the mental. Two pairs of chin shields, the posterior pair somewhat the longer; anterior pair in contact throughout their length; posterior pair separated by one narrow scale anteriorly and by two large scales posteriorly. Infralabials separated from the first ventral by 5 rows of scales. The rostral and internasals are somewhat scarred as a result of the snake's rubbing its nose on the wire cage lid during captivity.

Dorsal scales with two apical pits. Scale rows 23-21-19-17, all carinate throughout the length of the body and tail. Expressed in the Clark and Inger (recount) System (1942) the scutellation is as follows:

	87		104		142
	(4+5)		(4+5)		(3+4)
23	—	21	—	19	—
	(4+5)		(4+5)		(3+4)
	88		108		142

The ventrals are 151, plus a divided anal plate; subcaudals 79. The tail is terminated by a short blunt spine.

Eye comparatively large; the horizontal diameter of the orbit is 6.3 mm.; the distance from the orbit to the posterior border of the nostril is 7.0 mm.

Total length 1135 mm.; tail length 264 mm.; tail length/total length 23.3 per cent.

General dorsal coloration plain Dark Greyish Olive¹, but changing to somewhat paler on the lower flanks of the body. Top of head plain Olivaceous Black. General ventral coloration lemon yellow, but with a small amount of the dorsal hue encroaching onto the ends of the ventral scutes. On the posterior part of the belly there are dusky markings on the bases of the ventrals, these chiefly in the form of stippling. Underside of tail similarly colored and with dusky markings toward the bases of the subcaudal scutes; plain and slightly orange toward the tip. Anterior part of chin cream, but the posterior part of it, plus the labials (both upper and lower), match the lemon yellow of the belly. Posterior borders of labials margined with black, except for the second and third lower labials which are margined with orange brown. There is a trace of orange on each side of the neck somewhat below and posterior to the angle of the jaws. Pupil of eye black; iris Olive-Citron. Tongue pinkish grey toward base; tips medium grey.

PARATYPES.—The following specimens, all from Louisiana, are designated as paratypes:

CNHM 54002-4, all collected at the same time and place as the type. Also CNHM 54005-20, a litter of 16 young born to CNHM 54002 on September 5, 1947.

ANSP 25872 and CM 27834—Gramercy, St. James Parish.

AMNH 68693-4—6 miles east of Baton Rouge, Baton Rouge Parish. Also AMNH 68848 from Frenier Beach, St. John the Baptist Parish (the type locality), by Roger Conant, on March 30, 1948.

¹Capitalized colors throughout the text in accordance with Ridgway (1912).

CA 13861—Kenner, Jefferson Parish.

MCZ 49599-600 and USNM 125718—Westwego, Jefferson Parish.

UMMZ 96201—near Erwinville, West Baton Rouge Parish.

UMMZ 96202—Baton Rouge, Baton Rouge Parish, and UMMZ 96203-27 (25 young born to UMMZ 96202 on September 1, 1947).

VARIATION AMONG THE PARATYPES.—The general dorsal coloration in all the adult paratypes (5 ♂♂ and 8 ♀♀) is more or less uniform grey, olive grey, or brownish grey, but the general tone varies from snake to snake so that some individuals are darker than the type whereas others are distinctly lighter. Olive greys predominate, however, and it is usual for the flanks of the body to be paler and greyer than the middorsal area. In several of the paratypes, traces of the juvenile pattern still remain; among some of the smaller adults virtually all of the blotches (middorsal and lateral) are faintly indicated. In a few others, even in quite large specimens, there are pairs of short bars, slightly darker than the ground color, crossing the middorsal region; these represent vestigial traces of the dark edges of adjacent dorsal blotches. In two or three specimens the middorsal blotches are further represented by large, slightly dark areas along the back.

The belly coloration is yellow or lemon-yellow in all, although a few also exhibit a slight orange tone, especially on the throat, the sides of the neck, and toward the tip of the underside of the tail. The dorsal coloration encroaches onto the ends of the ventral plates and in most of the paratypes it also narrowly crosses the bases of the ventrals, at least on the posterior part of the body. The dark pigmentation on the belly is chiefly in the form of grey stippling and its intensity varies from specimen to specimen.

In a few there are traces of the paired light parietal spots that are usually strongly evident in the young.

Among the thirteen adults, the maximum number of scale rows is 23 in nine (in all five males and in four females), 25 in two, 26 in one, and 27 in one. The number of rows on the neck is 23 in all, the minimum number is 17 in all except four—in these it is 16 in one, 18 in one, and 19 in two. The upper labial count is 8 in all; the lower labials are normally 10, but in one male there are 11 on both sides of the head and in three females there are 11 on one side and 10 on the other. There is a single preocular in all, except in one snake that has 2 on one side. The postoculars are normally 3, but one snake has 2 on both sides of the head, another has 4 on both sides, and two have 4 on one side and 3 on the other. There is invariably a single anterior temporal. The temporals in the second row are most commonly 3, but in seven snakes there are only 2 on one side, and in one other there are 2 on both sides.

The ventrals in the males vary from 148 to 151 (mean 148.8); in females from 147 to 153 (mean 150.0). The subcaudals in males vary from 75 to 81 (mean 78.8); in females (only six with complete tails) from 65 to 70 (mean 66.5). The proportional length of the tails in males varies from 23.8 per cent to 25.8 per cent (average 24.8 per cent) of the total length; in females from 19.6 per cent to 21.6 per cent (average 20.9 per cent).

Two of the paratypes gave birth to young in captivity. These juveniles may be described as follows: Dorsal and lateral blotches very dark grey.

Top of head similar, but with poorly defined light olive markings on the snout, above the eyes, and in the temporal region. A pair of light spots, one on each side of the interparietal suture, and a light postparietal streak usually one scale in width but varying from one to three scales in length. Dorsal ground color variable from snake to snake, but ranging from orange brown to plain orange or light grey with an orange tinge. The hues are brightest on the neck; they become dull toward and on the tail. Chin and labials white or cream; labial sutures orange brown, those on the upper lip plates verging on black. Throat bright yellow; belly ground color bright to medium or pale yellow. A pair of narrow, black or dark grey, slightly curved bars on the base of each ventral scute, their long axes at right angles to the long axis of the body. Dorsal surface of tail more or less plain brownish grey; posterior half of under side distinctly orange.

In the two groups of juveniles the number of middorsal blotches varies from 27 to 37, of which the anterior 1 to 9 are fused with the adjacent lateral blotches to form dark crossbands. The single wild-caught juvenile among the paratypes (AMNH 68848) has 36 middorsal blotches which are alternated with the lateral blotches clear forward to the head.

In one litter (of sixteen young) the anal plate is single² in three specimens and in four others there is essentially only one scale covering the anus. In these, the normal imbrication is represented merely by a groove.

VARIATION WITHIN THE SUBSPECIES.—The normal amount of variation in *flavigaster* is exhibited among the paratypes. Occasional other specimens, however, may possess a great deal of dark pigmentation on the bases and ends of the ventral plates, this being particularly true toward the northern part of the range where this form intergrades with *neglecta*. Some individuals tend to have orange-yellow bellies. This is noticeably true toward the north and also to the east where *flavigaster* and *erythrogaster* intergrade.

RANGE.—Extreme southeastern Missouri and western Tennessee southward to the Gulf. The range of this snake embraces all of the states of Mississippi and Louisiana and all of Arkansas except the northwestern corner. To the west it occurs in extreme eastern Texas; to the east it is known from western Tennessee and extreme western Alabama.

Intergradation occurs with all three other races of the species—with *erythrogaster* in central Alabama, with *neglecta* near the head of the Mississippi Embayment, and with *transversa* through a broad area extending from northwestern Arkansas and eastern Oklahoma southward through east central Texas. For details see the paragraphs on intergradation for each of the other three races.

Another race of the red-bellied water snake, occurring in the Central Lowlands from southwestern Indiana to southern Michigan and western Ohio, may be called:

Natrix erythrogaster neglecta, ssp. nov.

NORTHERN COPPERBELLY

Plate I, fig. 1—a, b, c

TYPE.—No. 68695, American Museum of Natural History, now an adult

²The phenomenon of a single, instead of a divided, anal plate is of fairly frequent occurrence throughout the ranges of all four races of *erythrogaster*.

♀ but collected "in dam" July 23, 1932, approximately 3 miles east of Mount Victory, Hardin County, Ohio, by Roger Conant. The type was born September 30, 1932, and it and three paratypes (AMNH 68696-8) were raised to maturity in captivity.

DIAGNOSIS.—A large water snake of the genus *Natrix* that is characterized by a uniformly black or very dark brown dorsum and by the presence of red, scarlet, or reddish orange upon the abdomen. From other races of *erythrogaster* it may be distinguished by its coloration and by the marked tendency of the dark dorsal pigmentation to descend upon the belly, heavily involving the ends and bases of the ventral plates and often almost crowding out the red pigment on the posterior part of the belly. Among juveniles there is a strong tendency for the dorsal and lateral blotches to be fused irregularly.

The only other water snakes occurring in the same range and with which *neglecta* might be confused, are aberrant specimens of *Natrix sipedon sipedon*. These have proportionately smaller eyes and a lower number of ventrals (135 to 149, mean 141.1, compared with 144 to 158, mean 149.4, in *neglecta*).

DESCRIPTION OF TYPE.—Head shields arranged as in other members of the species; paired and bilaterally symmetrical internasals, prefrontals, supraoculars, and parietals. Nasals two, the anterior the larger and bearing the nostril entirely within it. Loreal medium small, about as long as high. One preocular and three postoculars. One temporal in the first row and three in the second; a small (azygous) scale cut off from the antero-lateral corner of the right parietal. Supralabials 8, the sixth the largest; the fourth and fifth enter the orbit. Infralabials 10, the sixth the largest and the first pair meeting on the chin posterior to the mental. Two pairs of chin shields (subequal in size); anterior pair in contact throughout their length; posterior pair separated by a long narrow scale anteriorly and two relatively broad wedge-shaped scales posteriorly. Infralabials separated from the first ventral by 5 rows of scales. All cephalic scales from the postoculars forward are slightly and irregularly rugose.

Dorsal scales with two apical pits. Scale rows 23-21-19-17, all carinate throughout the length of the body and tail. Expressed in the Clark and Inger (recount) System (*loc. cit.*) the scutellation is as follows:

	83		94		138
	(4+5)		(4+5)		(3+4)
23	—	21	—	19	—
	(4+5)		(4+5)		(3+4)
	84		94		134

The ventrals are 150, plus a divided anal plate; subcaudals 67 on the left side and 65 on the right (considered as 66 pairs for statistical purposes). Tail terminated by a short, relatively blunt spine.

Eye relatively large; orbit 6.7 mm. in horizontal diameter; the distance from the orbit to the posterior edge of the nostril is 7.5 mm.

Total length 1190 mm.; tail length 238 mm.; tail length/total length 20 per cent.

Dorsal coloration black, uniform, and completely without markings. Ventral ground color brilliant orange red (Flame Scarlet). Ventral plates heavily encroached upon by the black of the dorsum, especially toward the

rear of the belly. On the neck the dark coloration extends only onto the ends of the ventrals, but posteriorly it also occupies the bases of the gastroteges. At midbody the black involves more than half of each scale, and near the tail the red area is reduced to a narrow, irregular margin along the posterior edge of each of the belly plates. Underside of tail mottled with very dark grey and reddish orange, the grey greatly predominating except near the tip. Top of head black. Throat and chin whitish, passing through orange on the neck to the red of the belly. Labials dull orange red (Mars Orange), but with heavy encroachments of black on the upper and posterior portions of the supralabials and the last two infralabials; last upper labial completely black. The sutures between the anterior lower labials are deep reddish brown.

Shortly after birth this snake was described from life collectively with the seven other young of the same litter (Conant, 1934: 25) as follows:

The coloration. . . . of the dorsal and lateral blotches is black on a ground color of orange brown shading from Mars Orange to Sanford's Brown, although this color is paler in the narrow lines separating the adjacent dorsal blotches. Median blotches are three or four scales long and from nine to eleven scales wide. Lateral blotches are two or three scales wide and extend from the edges of the ventrals to the eighth or ninth row of scales. The belly is uniform orange, ranging from Bittersweet Orange to Orange Rufous, except for the anterolateral edges of the ventrals which are blackish. The labials are the same color as the belly but the sutures between them are darker and are almost black in some cases. There is a patch of white on the chin shields and gulars.

The average length of the juveniles soon after birth was 250 mm. Among the eight snakes of the litter (including the type), the number of dorsal blotches varied from 32 to 38 of which 2 to 6 of the most anterior ones were fused with the corresponding lateral blotches. At the age of one year (five snakes surviving) the pattern had become so obscure that it could be made out faintly only upon close examination or when the snakes were wet. The average length at that time was 467 mm.

PARATYPES.—The following specimens may be designated as paratypes:

TMS (Toledo Museum of Science) 1690 and AMNH 68696-8, the mother and litter mates of the type, respectively.

OSM (Ohio State Museum) 505, 605 and 674—all from 3 miles east of Mount Victory, Hardin County, Ohio (the type locality).

OSM 443; ANSP 25871—one mile southwest of Blakesley, Williams County, Ohio.

UMMZ 74510-1; USNM 30851-3—Olivet, Eaton County, Michigan.

CM 1520—Bluffton, Wells County, Indiana.

CM 9759—four miles west of Winslow, Pike County, Indiana.

VARIATION AMONG THE PARATYPES.—All sixteen of the paratypes (9 ♂♂ and 7 ♀♀) agree in having uniform black or very dark brown dorsums and in possessing a considerable amount of dark pigmentation upon the ends and bases of the ventral scutes. The belly has faded in all, but, among the eight paratypes that were alive when I first examined them, the ventral coloration varied from brilliant red or orange to brick red (Scarlet, Flame Scarlet, Orange Rufous, Dragon's Blood Red, and Pompeian Red in my notes).

The maximum number of scale rows in all is 23; thus none of the paratypes includes a count of 25, the highest noted for *neglecta* but which appears in only four of the eighty specimens studied. In ten paratypes

there are only 21 instead of 23 rows on the neck; the minimum number (just anterior to the vent) in all sixteen is 17. The upper labial count is 8 in all; the lower labials are 10, except that in two males and two females there are 11 on one side of the head. There is invariably 1 preocular and 1 anterior temporal. The postoculars are normally 3, but in four snakes the number is 4 on one side of the head and in another it is 4 on both sides; two additional specimens have only 2 on one side. There are usually 3 temporals in the second row, but in two snakes there are only 2 on one side; in an additional four there are 2 on both sides. The anal plate is single in one specimen (USNM 30851).

The ventrals in the males vary from 149 to 154 (mean 150.1); in females from 149 to 158 (mean 152.6). Only seven males and three females have complete tails. Subcaudal counts are 76 to 80 (mean 78.1) in these males and 64 to 66 (mean 65) in these females. The proportional length of the tails in the males varies from 22.8 per cent to 25.4 per cent (average 24 per cent) of the total length; in the females from 19 per cent to 20.7 per cent (average 20 per cent.)

VARIATION WITHIN THE SUBSPECIES.—The paratypic series, in general, exhibits about as much variation as is manifest in the population of *neglecta* as a whole, although slightly higher or lower scale counts appear occasionally.

Among juveniles of *neglecta* the number of dorsal blotches varies from 31 to 41 (mean 37) of which 2 to 11 of the most anterior ones are united with the adjacent lateral blotches to form dark crossbands. It is characteristic among the young of this subspecies for the dorsal and lateral blotches to run together irregularly (especially toward the rear of the body) so that the pattern is not clear-cut and the making of an accurate count (of the markings) often is difficult or even impossible.

RANGE.—South central Michigan and northwestern Ohio, southwestward through Indiana to near the mouth of the Wabash River (localities include Mt. Carmel, Illinois, and Henderson County, Kentucky).

Clay (1938: 181) included "extreme southern . . . Wisconsin" in the

PLATE I

(Read as though plate were turned with the snakes' heads to the left.)

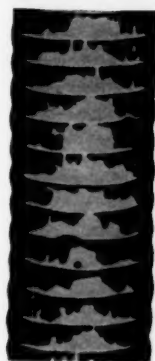
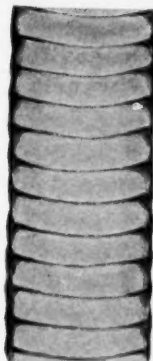
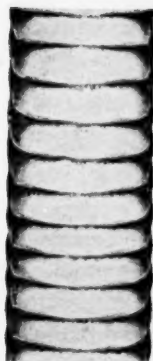
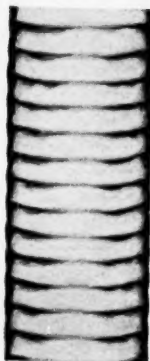
1. Top Row. *Natrix erythrogaster neglecta*. AMNH No. 68695 (type specimen), an adult ♀, 1190 mm. in length, from 3 miles east of Mt. Victory, Hardin County, Ohio. Painted from the preserved specimen and from Kodachromes of another living individual from the same locality.
2. Second Row. *Natrix erythrogaster erythrogaster*. An adult ♂, 868 mm. in length (at least a third of the tail missing), from Warner Robins (Wellston), Houston County, Georgia. Painted from life.
3. Third Row. *Natrix erythrogaster flavigaster*. CNHM No. 54001 (type specimen), an adult ♂, 1135 mm. in length, from Frenier Beach, St. John the Baptist Parish, Louisiana. Painted from life.
4. Bottom Row. *Natrix erythrogaster transversa*. Composite: scutellation based upon a preserved specimen from Mitchell Lake, Bexar County, Texas (a male 850 mm. in length); coloration and pattern based upon a series of living adults from central Texas. An attempt has been made to portray a more or less typical snake of this highly variable form. Each of the rows of figures shows (a) the left side of the head; (b) a lateral view at midbody; (c) the belly at midbody.

Plate reproduced from water color paintings by Edmond V. Malnate.

Roger
Conant

RACES OF *NATRIX ERYTHROGASTER*

PLATE I



unmarked

range of *erythrogaster*, obviously basing it upon Higley's (1889: 164) records for Beloit and Lake Geneva. If the red-bellied water snake occurs in that region at all, the subspecies *neglecta* would be expected. I prefer, however, to consider the matter unproved in view of the lack of specimens and because of the frequency with which *Natrix sipedon* and its races have been confused with *erythrogaster*. Garman's record (1892: 271) for Peoria, Illinois, possibly should be viewed with the same suspicion. It is perhaps significant that *erythrogaster* (= *neglecta*) has not been turned up in east central Illinois (Smith, 1947) or in the Chicago region (Schmidt and Necker, 1935; Necker, 1939; and Pope, 1944).

INTERGRADATION.—The population of snakes of the *erythrogaster* group inhabiting extreme southern Illinois, western Kentucky and Tennessee, and southeastern Missouri exhibits characteristics of both *neglecta* and *flavigaster*. Some individuals from this region are indistinguishable from typical specimens of one race or the other, but many have shades of coloration that are intermediate between the two. It is not uncommon to find snakes with black, dark brown, or dark grey backs in combination with yellow bellies; the converse is also true—greenish grey dorsums and orange venters. There is also considerable variation in the extent to which the dark pigmentation of the dorsum encroaches upon the ventral plates. Thus, in a series of nine (preserved and somewhat faded) adults from Reelfoot Lake (both Kentucky and Tennessee) the dorsal surface is uniform blackish brown in two, dark grey in five, and greenish grey in two; the ground color of the belly is yellow in three and orange yellow or orange in six; the amount of dark pigmentation on the belly might be considered slight in two, medium in three, and heavy in four. Also, among a series of seven specimens from extreme southern Illinois, there is a great deal of variation in coloration and the amount of dark pigmentation on the belly. In four of these snakes from near Wolf Lake, Union County, one is indistinguishable from *neglecta*; one could be identified as *flavigaster*; the other two (although faded) resemble *erythrogaster* from the southeast.

There is, as yet, no evidence of intergradation between *neglecta* and *erythrogaster*, but further collecting in Kentucky and Tennessee may close the gap between the known ranges of these two subspecies and prove that they actually intergrade. The two forms are obviously closely related, and they are connected through *flavigaster*.

Very dark specimens are sometimes found within the ranges of the other races. For example, all the copperbellies from southeastern Virginia that I have seen are typical of the eastern race (*erythrogaster*) except for one from Norfolk County (AMNH 68692). In it the dorsum is nearly black and the dark pigment encroaches considerably upon the otherwise orange belly. It could pass for a specimen of *neglecta* and so also could another snake (MCZ 13101) from Calhoun County, Alabama. Dark specimens also turn up occasionally in otherwise typical populations of both *flavigaster* and *transversa*.

REMARKS.—In the selection of a name for the northern race of *erythrogaster* I have investigated *Coluber fulviventer* of Rafinesque (1820: 6) and *Nerodia agassizii* of Baird and Girard (1853: 41). In my opinion *fulviventer*

is a *nomen nudum*. Rafinesque gives the number of ventrals as "about two hundred" which precludes the possibility of applying the name to any New World *Natrix*. Nor do I know of any snake in "Kentucky, Ohio, or Indiana" that combines the features of carinated scales, the high ventral count, and a coloration that is "entirely black above and brick-red beneath."

Baird and Girard's type (USNM 1350, from Lake Huron) is a somewhat aberrant specimen of *Natrix sipedon sipedon*. Although its ventral count of 146 lies within the range of variation of both that species and *neglecta*, the eye is proportionately quite small and the pattern is definitely that of *sipedon*. When the snake is immersed in preservative the dorsal and lateral blotches are readily visible. Since the epidermis has sloughed off, it is probable that the markings are more evident now than they were nearly a century ago, but suggestions of pattern were mentioned in the original description. The serpent, in life, probably resembled some specimens of *Natrix sipedon insularum*.

Doubtless a few persons may frown upon the choice of a captive born and raised snake as the type of a new subspecies. But the selection has been made for two reasons: (1) It appears fortunate to take advantage of a unique situation—being able to describe the same specimen in both the adult and juvenile conditions, especially since there is such a marked change associated with age and growth among snakes of this group; (2) The type and the other members of the same litter are among the very few specimens of *neglecta* from the Mount Victory locality that have complete tails and are otherwise in good condition. Careful comparison of the type with other individuals from several parts of the range reveals no differences of significance; scale counts fall well within the extent of variation of the form as a whole.

The subspecies *neglecta* faces a precarious future throughout most of its range. Drainage and agricultural activities have doubtless exterminated it in a great many localities, and it is disappearing now where it was common a few years ago. The colony at Blakesley, Ohio, apparently is now gone, and there is a strong possibility that the red-bellies living near Mount Victory, Ohio, may soon suffer the same fate. I know of several other localities in the Buckeye State where "red-bellied black snakes" supposedly once occurred, but there are no specimens to prove it. I have no recent information from Olivet, Michigan, or Bluffton, Indiana, where the species was once common, but advancing civilization may soon doom *neglecta* everywhere except in the lower Wabash Valley, where it may be expected to survive in the swamps of the river bottoms.

Natrix erythrogaster erythrogaster (Forster)

COPPERBELLY

Plate I, fig. 2—a, b, c

In concurrence with the restriction of the name *erythrogaster* to the southeastern race, it is advisable to select a neotype.

NEOTYPE.—No. 126890, United States National Museum, an adult ♀ collected March 19, 1948, near Parker's Ferry, Edisto River Swamp, Charleston County, South Carolina, by T. M. Beckett (through the courtesy of E. B. Chamberlain).

DIAGNOSIS.—A large unpatterned water snake with a uniform salmon-colored belly and a dorsum of rich reddish brown that changes to greenish on the flanks. The hues vary from specimen to specimen, ranging from reddish or chocolate brown above to pale brownish grey; the belly is most often salmon but may be any tone from orange red to pinkish. In general, the palest snakes come from the southernmost part of the range.

Adult specimens may be distinguished from adults of *flavigaster* and *neglecta* by their coloration, and from *transversa* by their lack of pattern. All other snakes of the genus *Natrix* (that occur within the range of *erythrogaster*) are normally characterized by strongly-patterned dorsums, strongly-patterned venters, or both. Occasional specimens of *erythrogaster* may exhibit some dark pigmentation on the antero-lateral portions of the ventrals, but this usually is not in strong contrast with the ground color of the belly. In the other species there are conspicuous spots, stripes, or blotches.

Juveniles are patterned like the young of *flavigaster* and *transversa*. For ways of distinguishing between the young of this species and the young of other water snakes see the diagnosis for *flavigaster*.

DESCRIPTION OF NEOTYPE.—The scutellation, in all essentials, is similar to that of the types of *flavigaster* and *neglecta* that have been described above. Counts may be summarized as follows: Scale rows 23-21-19-17; ventrals 148; subcaudals 71 pairs; supralabials 8; infralabials 10; oculars 1-3; temporals 1-3. Many of the cephalic scales are scarred, especially on the right side of the head. The horizontal diameter of the eye is 7.4 mm.; the distance from the eye to the posterior border of the nostril is 7.6 mm.

Total length 1318 mm.; tail length 271 mm.; tail length/total length 20.6 per cent.

Dorsum unpatterned; general coloration medium dark brown (Saccardo's Umber), but becoming paler, slightly greenish, and lightly stippled with grey on the lower flanks. Top of head Chestnut-Brown. Top of tail slightly richer in tone (Mars Brown) than dorsum of body. Belly Salmon-Orange to Orange Chrome; antero-lateral portions of ventrals stippled with grey. Chin whitish but heavily washed with orange; throat chiefly orange but with some white showing through. Under side of tail Apricot Orange. Labials Ochraceous-Orange, each supralabial bordered posteriorly with dark brown; infralabials bordered posteriorly with reddish brown. Pupil of eye black, narrowly bordered by yellow; iris Mummy Brown. Tongue reddish brown, changing to grey on the tips.

RANGE.—From the Pocomoke River, in the Eastern Shore portion of Maryland, southward, chiefly in the Coastal Plain, to northwestern Florida. The range of this snake extends into the Piedmont Province in the Carolinas, Georgia, and Alabama. I have already commented upon the northernmost limit of *erythrogaster* in the east (Conant, 1943) and have shown that Pennsylvania records for the species (Dunn and Allen, 1935) are erroneous.

INTERGRADATION.—Where the ranges of *erythrogaster* and *flavigaster* meet in Alabama, snakes are found that combine the characteristics of the two forms. Thus, in two specimens from Elmore County (central Alabama)

the upper surface is dark olive (as in many *flavigaster*), but the abdomens are orange (as in *erythrogaster*). Another specimen from adjacent Coosa County is dark brown (Clove Brown) above, Deep Olive on the flanks, and dull orange (Apricot Orange) on the belly and under the tail; it could pass for a typical *erythrogaster*. Another specimen from Sumter County (extreme west central Alabama) possesses all the color characteristics of *flavigaster*. There is a comparative dearth of material from Alabama, and an examination of more living material may show that the area of intergradation is fairly large and that it extends at least from north central Alabama to the Gulf of Mexico.

Natrix erythrogaster transversa (Hallowell)

BLOTCHED WATER SNAKE

Plate I, fig. 4—a, b, c

The subspecies *transversa* may be characterized as a race of *erythrogaster* in which the juvenile pattern of dorsal blotches and alternating lateral spots is retained more or less throughout life. Even quite large snakes may be strongly marked and they may also exhibit such other essentially juvenile characteristics as paired light parietal spots, a light post-parietal spot or streak, and a pair of narrow dark or dusky markings on the base of each ventral scute. In many, the tones of both the markings and the ground color are quite rich. Very large (probably old) specimens of both sexes may be virtually uniform dark brown or olive above, or there may be mere traces of pattern in the form of pale, dark-bordered crosslines in the mid-dorsal area.

In all the other subspecies of *erythrogaster* it is normal for adult specimens to be uniform or nearly uniform in dorsal coloration. In them the juvenile pattern disappears entirely or almost entirely.

Snakes of the subspecies *flavigaster*, particularly those exhibiting traces of pattern, have often been confused with *transversa*. Both forms may have yellow bellies, hence there is no wonder that snakes, even from the Mississippi Valley, have been classified as *transversa* and so reported in the literature. Although there is considerable individual variation, it should be borne in mind that population samples of *transversa* include a strong preponderance of snakes with patterns, whereas population samples of *flavigaster* include a large majority of plain (or nearly plain) specimens.

RANGE.—Eastern and southern Kansas; southward, through most of Oklahoma and central and western Texas, into Mexico; known from the Pecos River in extreme southeastern New Mexico.

INTERGRADATION.—There is a broad area of intergradation between *flavigaster* and *transversa*, the boundaries of which are difficult to define. Based upon the relatively large amount of material I have seen to date, this includes southeastern Kansas, eastern Oklahoma, extreme northwestern Arkansas, and most of eastern Texas west to the Balcones Escarpment. (Extreme eastern Texas is inhabited by *flavigaster*.) Throughout the broad zone of overlapping there is a gradual change from the characteristics of *flavigaster* toward the east to those of *transversa* toward the west. It is futile to attempt assigning individual snakes from this area to either

TABLE I
COLOR AND PATTERN CHARACTERISTICS OF THE RACES OF *Natrix erythrogaster*

SUBSPECIES	ADULTS					JUVENILES
	DORSUM	VENTER	REMNANTS OF JUVENILE PATTERN	PARIETAL SPOTS AND POST-PARIETAL STREAK	DARK PIGMENT ON BELLY	
<i>erythrogaster</i>	UNPATTERNED Chocolatte brown; varying from rich reddish brown to pale brownish grey; often greenish on the flanks	Usually salmon, but varying from pale pinkish orange to orange red	Occasional specimens show faint light crossbands in the middorsal region	Usually absent	Normally none, or only a little and of a relatively pale hue	Pattern usually clean-cut, but fusing of blotches occurs occasionally
<i>flavigaster</i>	UNPATTERNED Olive grey; varying from pale grey to dark greenish grey	Yellow or lemon	Many specimens show traces of light crossbands in the middorsal region	Sometimes present	Normally with only a little and of a relatively pale hue	Pattern usually clean-cut, but fusing of blotches occurs occasionally
<i>neglecta</i>	UNPATTERNED Black or very dark brown	Red or scarlet; sometimes orange red	Almost always absent	Almost always absent	Often profuse and almost always black or dark brown	Pattern confused, the lateral and middorsal blotches usually fusing irregularly and making counting difficult
<i>transversa</i>	WELL-PATTERNED Ground color grey; tan, olive, or brown; blotches darker and usually with dark edges (large adults sometimes are almost uniformly dark)	Yellow or orange yellow	Strong indications usually remain throughout life	Almost always present (except in large adults)	Often encroaches onto ends of ventrals from dorsum; many specimens have a pair of narrow dark, curved markings on the base of each ventral	Pattern clean-cut

the one form or the other. Identification must be based upon an analysis of large samples of specimens, but the population as a whole may be designated as *Natrix erythrogaster flavigaster* x *transversa*.

DISTINCTIONS BETWEEN *transversa* AND *Natrix sipedon sipedon*.—Many herpetologists have confused *transversa* with *Natrix sipedon sipedon*, especially where the two species occur together in Kansas and Oklahoma. Scutellation is so similar in both that it cannot be relied upon for diagnostic purposes, except in those specimens of *sipedon* that have fewer than 140 ventral scutes (the minimum for *transversa*) and in the few specimens of *transversa* that have maxima of 27 rows of dorsal scales. Counts higher than 25 have not been recorded for *sipedon*.

There are basic pattern differences, however, that will serve to distinguish specimens. In *transversa* the lateral blotches alternate with the dorsal blotches almost throughout the length of the body; in *sipedon* the dorsal and lateral markings are fused to form dark crossbands on at least the anterior part of the body. Similar fusing occurs in *transversa*, but in that species only a few blotches on the neck are normally involved; in *sipedon* the fusing may extend backward almost to midbody or even beyond.

The belly pattern is especially diagnostic. In *sipedon* the undersurface usually is boldly pigmented, the markings most often being in the form of dark half-moons which may or may not have red or chestnut centers. In contrast, *transversa* has an unpatterned belly or, if dark pigmentation is present, it is confined to the bases of the ventrals or to a pair of dusky markings on the anterior portion of each ventral scute. Both species may have dark markings under the tail, especially near the anus. In *sipedon* these usually continue to the tip, but in *transversa* the undersurface near the tip of the tail is unpatterned and may be yellow, orange, pink, or reddish in life.

It should be remembered that most specimens of *transversa* have paired light parietal spots and a postparietal streak or spot, characteristics that normally are absent in *sipedon*. There is also a tendency for the heads of specimens of *transversa* to bear some reddish-brown pigment, especially in the temporal region.

IN GENERAL

This study is based upon the examination of 647 snakes from all parts of the range of the species as a whole. Although a great many were seen alive, the bulk of the material has consisted of museum specimens, most of them considerably faded. Largely because of this fact it is impossible to define the ranges with exactness, a difficulty that may eventually be overcome by the acquisition of living serpents from critical localities. A detailed range map will accompany "Studies on North American Water Snakes—III; the Subspecies of *Natrix erythrogaster*" which is now in preparation.

There is remarkably little variation in scutellation among the several races of *erythrogaster*. Scale counts and other statistical matter will be summarized in the forthcoming paper. In it, also, full acknowledgement will be made to the many persons who have aided me by lending specimens, supplying notes, or making special excursions afield on my behalf.

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Notes on Snakes Collected in Liberia

By M. S. BRISCOE

THE west African Republic of Liberia has an area of approximately 43,000 square miles. It lies between $4^{\circ} 22'$ to $8^{\circ} 50'$ north latitude, and $7^{\circ} 33'$ to $11^{\circ} 32'$ longitude west of Greenwich, and has one of the most humid and rainiest climates of Africa. Most of the country is covered by hills of varying heights. A mixed forest is the predominant vegetation of the hinterland. The typical vegetation of the coastal belt, however, is open grassland with patches of bracken fern (*Pteridium aquilinum*) and trees of the "monkey plum" (*Parinarium macrophyllum*). This belt is flat and characterized by creeks and tidal lagoons which are fringed with mangrove trees (*Rhizophora mucronata*).

While stationed in Liberia (1943-1945) I had the opportunity to study the herpetology of various parts of the country.

Notes on the species of snakes collected follow:

Calabaria reinhardtii (Schlegel).—Several of these curious calabaria were found moving sluggishly over a thick layer of decaying leaves on the forest floor; this is ideal for burrowing snakes. A characteristic habit was to curl the body into a tight ball when approached. None of them made any attempt to bite when handled. Natives, on the other hand, believe them to be dangerously poisonous. These snakes were found at Roberts Field, Harbel and Paiata.

Natrix anoscopus anoscopus (Cope).—This snake was not found at any great distance from water. And, too, it did not seem to be well established or abundant at Roberts Field where it was collected. Specimens were seen on logs and low bushes overhanging water. A favorite shelter was under vegetation or stones which were partly submerged along the edge of a stream.

Boaedon lineatus lineatus (Duméril and Bibron).—Found under raised buildings and in shaded roadside ditches close to native villages at Harbel and Roberts Field. These seemed to be preferred situations for none of these snakes were seen at any great distance from human habitations. They were somewhat phlegmatic and offered very little resistance when captured.

Boaedon lineatus virgatus (Hallowell).—A single specimen was taken in low bush at Roberts Field. It remained motionless when first encountered. Further search failed to reveal others.

Thrasops occidentalis Parker.—This rare tree snake, the second known female, was captured while it was moving slowly across a dirt road at Roberts Field during the dry season. It is the largest example known, measuring 1565 mm. in length, and the first of its species to reach any museum in the United States. It has been deposited in the National Museum (USNM 122257). According to the scale count made by Loveridge there are 187 ventrals, 2 anals and 132 subcaudals.

Boiga pulverulenta (Fischer).—A few of these snakes were observed basking in the sun in an area adjacent to Roberts Field. They moved with alacrity when approached and secreted themselves in low bush. Specimens

hiding in these places usually could not be found again due to the dense vegetation.

Boiga blandingii (Hallowell).—A single individual was found in the matted vegetation at the base of a rubber tree (*Hevea brasiliensis*) at Harbel. It was quite aggressive when encountered. This is a large example of Blanding's tree snake, measuring 1973 mm. in length. As a rule this species seldom exceeds 6 feet.

Psammophis sibilans phillipsii (Hallowell).—These specimens were found at Roberts Field in an area that was being cleared of underbrush, tree trunks, lianas and aerial roots. They exhibited much agility when encountered and were rather difficult to catch.

Thelotornis kirtlandii kirtlandii (Hallowell).—This slender snake was concealed in the foliage on the lower branch of a tree overhanging a pond which was being cleared of water-lilies. It is a juvenile and was found at Roberts Field.

Miodon acanthias (Reinhardt).—This snake is rare. Our specimen, a male and probably the tenth known example, has been deposited in the National Museum (USNM 122250). It is a juvenile and measures 186 mm. in length. The area at Roberts Field where it was captured was thickly populated with the false date-palm (*Phoenix reclinata*) and high bush. This afforded an ideal retreat and made capture very difficult. According to the scale count made by Loveridge there are 188 ventrals, 1 anal and 22 sub-caudals.

Aparallactus modestus (Günther).—A few of these snakes were found beneath thick clusters of leaves near irrigation ditches at Harbel and Roberts Field. When discovered they made their way to other places of concealment, such as old logs and strips of bark scattered over the forest floor. Moist environments appeared to be the favorable habitats.

Dendroaspis viridis (Hallowell).—The mambas (tree cobras) are well represented in Liberia. They were usually seen in trees overhanging trails in search of small birds. Occasionally they come indoors. I almost stepped on one coiled on a concrete floor. Several of these snakes were captured beneath raised buildings at Roberts Field where it was damp and cool. Others were collected at Harbel, Monrovia and Gbanga.

Causus rhombeatus (Lichtenstein).—This viper is quite common in Liberia. Although it may appear harmless to the observer it is a pugnacious snake. Almost every one collected exhibited an aggressive disposition. Most of my specimens were collected in such diverse places as rubbish heaps, dry sandy areas and low bush at Harbel, Monrovia and Kakata. Some were found beneath raised buildings at Roberts Field.

Bitis gabonica (Duméril and Bibron).—The gaboon viper is the largest (but not the longest) poisonous snake in Africa. Its thick bloated body and great bulging poison sacs give it a most sinister aspect. Despite its awe-inspiring appearance this dangerously poisonous snake is surprisingly good-natured. Those encountered at Roberts Field and in dense forests near Lengtowntown showed no tendency to attack.

Bitis nasicornis (Shaw).—This viper occurred chiefly in dense forests near Memeta. Though one of the most venomous snakes known it is slow to strike.

Atheris chloroechis (Schlegel).—These little tree vipers were captured on leafy branches of low bush at Roberts Field and Harbel. Their color was excellent camouflage. When they remain rigid they can easily be mistaken for a stem.

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The Aortic Arches and Associated Arteries of Caudate Amphibia¹

By REZNEAT M. DARNELL, JR.

SEVERAL authors have attempted to work out the phylogenetic pattern of the caudate Amphibia, basing their efforts mainly upon the presence, absence, or extent of certain skeletal elements, the cranial nerve distribution, and the components of the auditory apparatus. The most notable of these attempts, Cope (1889), Kingsbury (1905), Reed (1920), and Dunn (1922), while successful in dividing the order Caudata into well-defined families, have not been entirely successful in establishing the inter-family relationships of this group, in which are encountered such perplexing degrees of neoteny.

In the present work an attempt is made to throw some light upon the true relationships of some of the families whose affinities are uncertain. Employing modern methods and materials a study has been carried out on the aortic arches and associated arteries in representative types of 6 of the 8 families of the order Caudata. Descriptions are supported by original drawings, and comparisons are made of the conditions present in the different families.

The author wishes to express his sincere appreciation to Dr. Edgar Altenburg and Dr. Asa C. Chandler for their helpful suggestions and criticisms during the course of this study, and to Dr. C. L. Baker, who aided in working out the injection technique and at whose suggestion the work on *Siren* and *Amphiuma* was initiated. Thanks are also due to Dr. Robert Kroc of the Maltine Company for generously supplying thyroid extracts used in reducing the gills in *Siren lacertina*.

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MATERIALS AND METHODS

The species employed in this study to represent the 6 families were as follows, *Siren lacertina*, Sirenidae, *Necturus maculosus*, Proteidae, *Amphiuma tridactylum*, Amphiumidae, *Ambystoma texanum*, Ambystomidae, *Triturus viridescens*, Salamandridae, and *Plethodon glutinosus*, Plethodontidae.

Injections of the circulatory systems were made with polymerized vinyl acetate dissolved in acetone. Several portals of entry for the injection fluid were tested with varying results. Best results were achieved in large specimens (10-40 inches long) by injecting directly into the dorsal aorta, sending the fluid against the normal direction of blood flow. On smaller specimens it was found that injections into the ventricle yielded best results. A single injection was sufficient in most types to leave all the desired vessels injected, the one exception being *Necturus*. In this form double injection was necessary, the first into the dorsal aorta, and the second into the ventricle.

The calibre of the needle used was determined by the size of the specimen, and in this study No. 18, 20, 26, and 27 gauge needles were used.

Employing the methods described above, good injections were secured on salamanders whose length varied from 1.9 inches in the smallest *Triturus* to 37 inches in the largest *Amphiuma*. After the injection was completed it was allowed to 'set' for several minutes, and then, the posterior portion having been removed, the injected anterior end was placed in a concentrated aqueous solution of potassium hydroxide. In from 3 to 7 days all except the largest specimens were completely dissolved away from the plastic replica of the circulatory systems.

The specimens were observed periodically as they were being macerated and dissections were carried out on some injected specimens. But the latter procedure was not always followed since this study was not intended as a description of the various peripheral ramifications of the arteries discussed.

During the course of the study it was found desirable to cause *Siren* to lose its gills. For this purpose 'Proloid,' an extract of the thyroid gland, was employed. Success was achieved by four subcutaneous injections of 100 mg. each of the extract in 3 cc. of water at intervals of 7-8 days. Two weeks after the last injection, when the gills were completely non-functional and almost completely absorbed, the amphibian was anesthetized and the circulatory system was injected with plastic.

All injections were thoroughly studied, using a binocular microscope for examination of small specimens and for details of the larger ones. Special attention was paid to the point of origin and method of origin of the various arteries. Original composite drawings were made from the injections. The more usual conditions were reproduced in the drawings, and all observed major or frequent variations are recorded at appropriate places in the text.

DESCRIPTION OF ARTERIES OF CAUDATA

SIRENIDAE

(Fig. 1)

The following description has been prepared from injections of 6 large specimens of *Siren lacertina*.

The vascular systems of *Siren* and of *Necturus* are of particular interest because of the information they yield regarding the ontogeny and phylogeny of these amphibians, which will be discussed in greater detail later.

In *Siren* 3 aortic arches are present, the *carotid* or *third aortic arch*, the *systemic* or *fourth aortic arch*, and the *pulmonary* or *sixth aortic arch*. No trace of a '*third*' or *fifth aortic arch* has been found in any specimen examined. External gills are normally present in adult *Siren*, and in the following discussion the *carotid*, the *systemic*, and the *pulmonary arches* will be referred to as *afferent* and *efferent branchials* I, II, and III.

The *first afferent branchial artery* arises from the *truncus arteriosus* and passes antero-laterally to the first gill where it gives off generally 9 paired lateral branches which in turn give off lateral capillaries within the filaments of the gill. Before reaching the gill the *first afferent* gives off from 7 to 9 small connections to the ventro-mesial continuation of the *first efferent*. Proximal to these *gill by-passes* the *first efferent* turns anteriorly as the *external carotid* and gives off a mesial branch which parallels the *first afferent* to the mid-ventral line where it anastomoses with its homologue from the opposite side and continues posteriorly, supplying the walls of the *truncus* and the *conus arteriosus* with blood. The *efferent rami* in the first gill unite into one vessel which joins the ventral loop of the *first efferent* distal to the *gill by-passes*. After receiving the *efferent* branch from the first gill, the *first efferent branchial* makes its dorsal loop, heads mesially and somewhat posteriorly, and about halfway to the mid-line it abruptly turns anteriorly as the *internal carotid*. At the angle of origin of the *internal carotid* a thick branch is received which takes origin from the fused *second* and *third efferents*.

The *second afferent branchial* parallels the *first* and passes to the second gill where it gives off paired side branches as in the first gill. The *second efferent* arises from small *efferent rami* in the gill and, after receiving the *third efferent*, progresses mesially and then posteriorly to where it fuses with its mate from the opposite side to form the *dorsal aorta*. Just after leaving the gill the *second efferent* receives blood by means of a large loop which arises by from seven to nine small connections with the *second efferent* immediately proximal to the gill. The *second efferent* passes mesially, receives the *third efferent*, and gives off the large aforementioned branch to the *internal carotid*. The fused *second* and *third efferents* continue to the midline as the *dorsal systemic arch* which meets its fellow from the opposite side and passes posteriorly as the *dorsal aorta*. About halfway between its connection with the *internal carotid* and the mid-line the *dorsal systemic* gives rise to a large artery, the *palatino-nasal*, which passes to the roof of the pharynx and mouth. After passing anteriorly for a good distance the *palatino-nasal* gives rise to a large branch which turns mesially, and then posteriorly to dip into the vertebral column as the *vertebral artery*.

The *third afferent* arches anteriorly and then posteriorly into the third gill which has the same type of structure as the first 2 gills. The *third efferent* originates as rami in the gill and after leaving the gill in a mesial direction, turns abruptly forward (as the *ductus Botalli*) to where it fuses with the *second efferent*. The *pulmonary artery* arises as a mesial continuation of the *third efferent* just after the latter emerges from the gill. It presently turns posteriorly to supply the lung. Normally 4 rather large connections proximal to the gill unite the *third afferent* with the *third efferent* and *pulmonary artery*.

It should be noted that for every gill, shunts or *gill by-passes* are present

which permit the blood from the heart to reach the general circulation without having to enter the gills. When *Siren* is caused to lose its gills by the action of thyroid extracts, the *gill by-passes* take over the function of trans-

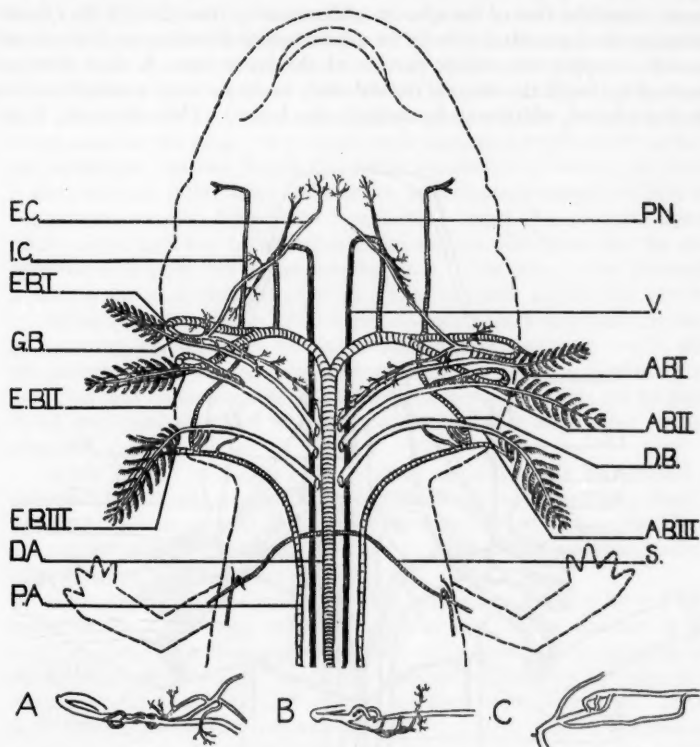


Fig. 1. *Siren lacertina*. Composite drawing of plastic replicas of the anterior arteries. A, B, C, aortic arches after gills have been lost.

Abbreviations used in figures (terminology adapted from Francis, 1934). A.III. Carotid arch. A.IV. Systemic arch. A.V. 'Third' arch. A.VI. Pulmonary arch. A.B.I. First afferent branchial. A.B.II. Second afferent branchial. A.B.III. Third afferent branchial. A.P. Ascending pharyngeal. D.B. Ductus Botalli. C.B. Carotid bulb. D.A. Dorsal aorta. E.(Es.). Esophageal. E.B.I. First efferent branchial. E.B.II. Second efferent branchial. E.B.III. Third efferent branchial. E.C. External carotid. G.B. Gill by-pass. I.C. Internal carotid. L. Lung. P.A. Pulmonary. P.N. Palatino-nasal. P.V. Pulmonary vein. S. Subclavian. V. Vertebral.

porting the blood from the *afferents* to the *efferents*. In the *carotid arch* the *gill by-passes* become reduced in number, thickened, and twisted around each other. In the other arches one of the shunts seems to take over while the remainder degenerate.

PROTEIDAE (Fig. 2)

This description has been made from examination of 8 injections of medium-sized specimens of *Necturus maculosus*.

The *first afferent* passes laterally and then dips posteriorly into the first gill where it gives off 10 to 15 unpaired branches from its ventral aspect. Each of these branches breaks up into a considerable number of bush-like capillaries in the gill filaments. The structure of the *efferent* in the gill closely resembles that of the *afferent*. After passing from the gill the *efferent* continues on the ventral side in an antero-mesial direction as the *external carotid* to supply the middle portion of the lower jaw. A short distance proximal to the gill the *external carotid* often receives a small connection from the *first afferent*, which may be multiple (see below). This, obviously, is the

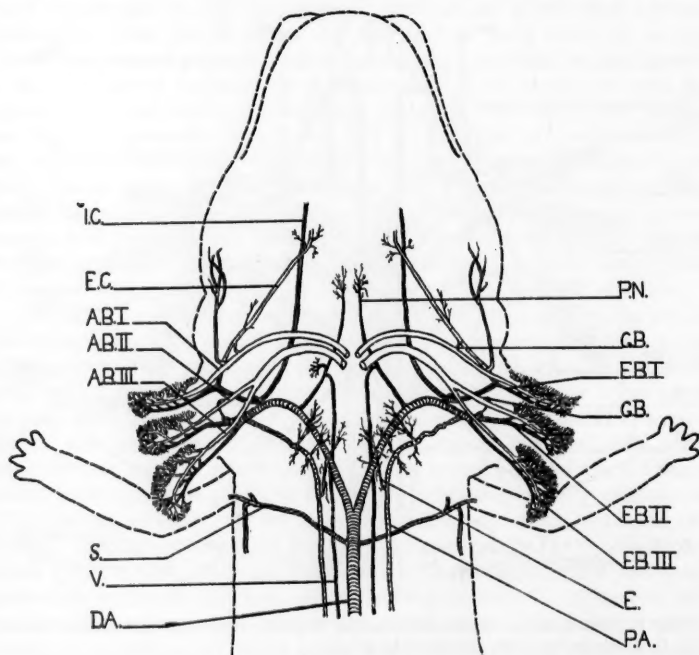


Fig. 2. *Necturus maculosus*. Composite drawing of plastic replicas of the anterior arteries.

persisting *gill by-pass* which in *Siren* is always multiple. About midway between the gill and the *gill by-pass* the *external carotid* gives rise to a small, but often conspicuous vessel which passes directly anteriorly supplying the lateral muscles of the pharyngeal region. Midway between this latter vessel and the first gill the *first efferent* turns dorsally, arches posteriorly, receives a branch from the fused *second* and *third efferents* and continues anteriorly as the *internal carotid*.

The *second* and *third afferents* are fused at their origin and after proceeding antero-laterally for a short distance, arch somewhat posteriorly,

divide into 2 branches and proceed to the second and third gills respectively. The second and third gills resemble the first in the structure of the *afferent* and *efferent rami*. After leaving the gills the *second* and *third efferents* unite to form the *dorsal systemic arch*. This arch proceeds anteriorly for a short way, and then posteriorly to the level of the fore-arm to fuse with its mate from the opposite side forming the *dorsal aorta*. Just before joining the *third efferent*, the *second efferent* receives a rather prominent branch from the *second afferent*, a *gill by-pass*. Immediately after the junction of the *second* and *third efferents*, a posterior branch is given off, the *pulmonary artery* which supplies the lung. This vessel sends numerous small side-branches to the esophagus. Shortly before the *dorsal systemic arch* swings posteriorly, it gives rise to a rather large vessel which passes antero-laterally to fuse with the *internal carotid*. This vessel is somewhat larger than its homologue in *Siren*. About half way between this vessel and the mid-dorsal line the *dorsal systemic arch* gives rise to the *palatino-nasal*. This artery, after proceeding anteriorly for some distance, gives off a large posterior branch, the *vertebral*.

Miller (1900) correctly figured and described the pharyngeal circulation of *Necturus*, but his main drawing is somewhat confusing in that it shows the *external carotid* arising from the *first afferent* rather than the *first efferent branchial arch* on the left side. His drawings also show multiple *gill by-passes*; in all specimens examined in the present study they were either single or absent.

Noble (1931) reproduced the drawing of Miller, but he labelled the *external carotid* only on the left side, which shows it stemming from the *afferent*, and in the context he described the vessel as arising from the *afferent*. Subsequent authors incorrectly show the *external carotid* stemming from the *afferent* rather than from the *efferent*.

In the present study 4 specimens of *Necturus* were injected by way of the ventricle alone. In these injections none of the *efferent* arteries or their branches (including the *external carotid*) were found to be injected, even though the *afferents* were completely injected. Injections by way of the *dorsal aorta* alone left only the *efferents* and their branches injected. In these injections the *external carotid* was completely injected. Double injection with contrasting colors showed definitely that the *external carotid* stems from the *efferent*, although it may closely parallel the *afferent* dorsally for a good distance before continuing to the lower jaw.

AMPHIUMIDAE

(Fig. 3)

The following study was made from examination of injections of 3 large *Amphiuma tridactylum*.

The adult *Amphiuma* has no gills, and the pharyngeal arteries of this caudate are somewhat different from those of the two previously described types. Three aortic arches persist, the *carotid*, the *systemic*, and the *pulmonary*.

The *carotid arch* is directed antero-laterally at about a 45° angle. *Gill by-passes* are not present as such, but they have given rise to the *carotid bulb* (or *carotid gland*), a prominent enlargement of the *carotid* made up of a number of fine conjoining tubules. The *external carotid* arises from the dorso-

mesial edge of this structure and passes to the lower jaw. Distal to the *carotid bulb* the *internal carotid* makes its loop dorsally and then, after receiving a connecting branch from the *systemic*, passes to the head region. This connecting branch in *Amphiuma* is relatively much longer than its homologue in *Siren* and *Necturus*, and it regularly displays a prominent side-branch that supplies the lateral muscles of the pharyngeal region.

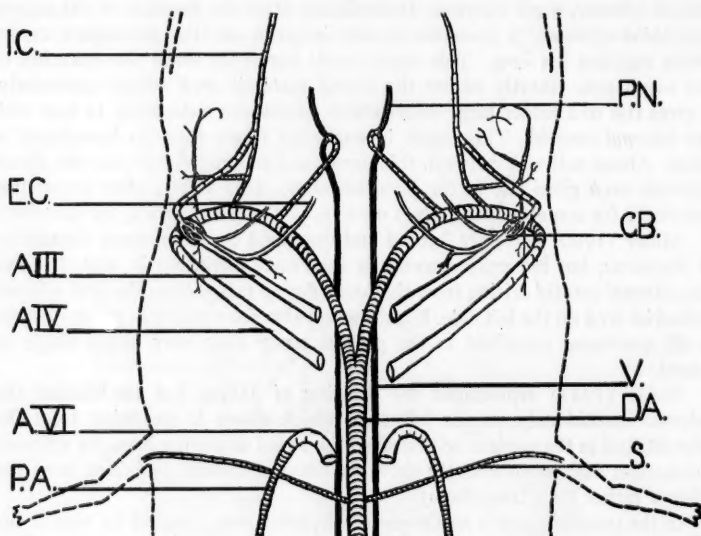


Fig. 3. *Amphiuma tridactylum*. Composite drawing of plastic replicas of the anterior arteries.

As it leaves the *truncus arteriosus* the large *systemic arch* parallels the *carotid*. The *systemic* makes its dorsal loop and then directs itself posteriorly to a position slightly anterior to the fore-limbs where it fuses with its mate from the opposite side to form the *dorsal aorta*. Two large branches are given off by this arch, the connection with the *internal carotid* and the *palatino-nasal*. The *vertebral* arises as a posterior branch of the *palatino-nasal* after the latter has progressed in an antero-mesial direction for quite some distance.

The *pulmonary* arises from the *truncus arteriosus* at the level of the fore-limb and immediately loops posteriorly. No *ductus Botalli* is present.

AMBYSTOMIDAE

(Fig. 4)

The following description has been prepared from examination of injections of 5 medium-sized *Ambystoma texanum*.

In *Ambystoma* 4 arches are normally present, the *carotid*, the *systemic*, the 'third' arch or *fifth aortic arch*, and the *pulmonary*. However, the 'third' arch is partially fused with the *systemic* on both sides.

The *carotid* passes laterally from the *truncus arteriosus*, gives off the *external carotid*, and passes dorsally, then anteriorly to the cranium as the *internal carotid*. The *external carotid* arises as a dorso-mesial branch of the large *carotid bulb* as in *Amphiuma*.

The *systemic* passes laterally to the level of the *carotid bulb* somewhat paralleling the *carotid arch*, dips dorsally, and then loops mesially to fuse

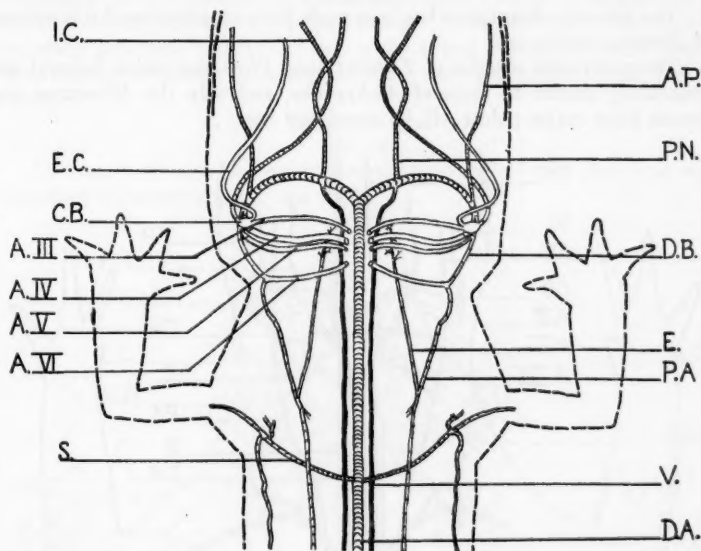


Fig. 4. *Ambystoma texanum*. Composite drawing of plastic replicas of the anterior arteries.

with its fellow from the opposite side. The fused *systemics* pass toward the tail in the mid-dorsal line as the *dorsal aorta*. Three major arteries are given off by the *systemics* before they fuse, the *ascending pharyngeal*, the *palatino-nasal*, and the *vertebral*. In *Ambystoma* no connection is normally present between the *systemic* and the *internal carotid*. However, the *ascending pharyngeal*, which supplies the periphery of the lower jaw, originates from the same locus on the *systemic*, and in one specimen it had anastomosed with the *internal carotid*, the 2 arteries separating further on.

The *palatino-nasal* and *vertebral* arise separately and on opposite sides of the *systemic*, and the latter passes posteriorly for a short distance before dipping into the vertebral column.

The 'third' arch parallels the *systemic*, receives the *ductus Botalli*, bends dorsally, and immediately joins the *systemic* just before the latter gives off the *ascending pharyngeal*.

The *pulmonary* leaves the *truncus arteriosus* a short distance posterior to the anterior arches and does not quite parallel them, passing in a more pos-

teriorly direction. At its lateral extremity the *pulmonary* gives off the *ductus Botalli* and then proceeds caudally and somewhat mesially to the lungs. At about the level of the fore-limb the *pulmonary* artery gives rise to a large branch, the *esophageal artery*, which passes anteriorly to supply the esophagus.

SALAMANDRIDAE

(Fig. 5)

The following description has been made from examination of 6 injections of *Triturus viridescens*.

The pharyngeal arteries of *Triturus* (and *Plethodon* which follows) are remarkably similar to those of *Ambystoma*, and only the differences and certain other major points will be mentioned here.

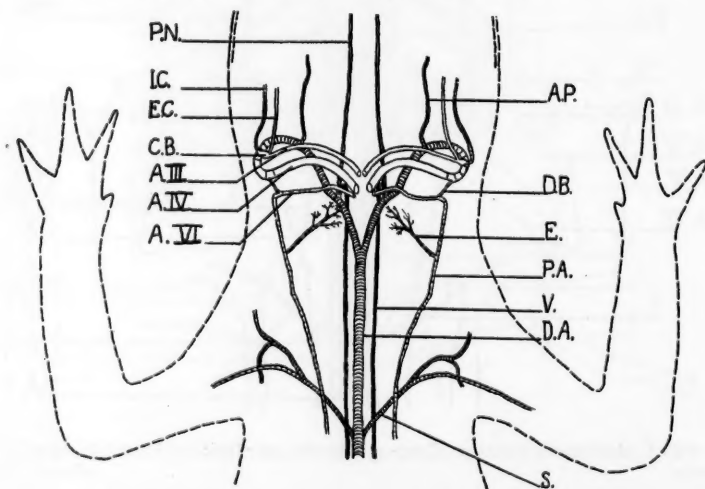


Fig. 5. *Triturus viridescens*. Composite drawings of plastic replicas of the anterior arteries.

In the present study no specimen of *Triturus* has been observed to have more than 3 aortic arches. (Francis, 1934, records that in *Salamandra*, also of the family Salamandridae, the rule is 4 rather than 3.) Close inspection of the *systemic* in *Triturus* reveals that the 'third' arch is in reality fused along its length with the *systemic*, the degree of fusion varying in different specimens.

The *carotid bulb* is present, and the *external* and *internal carotids* arise as in *Ambystoma*.

In *Triturus* the *systemics* proceed posteriorly a good distance behind the level of the *pulmonary* before fusing to form the *dorsal aorta*.

The *ascending pharyngeal* arises more mesially than in *Ambystoma*. The *vertebral* arises on the cranial side of the *systemic* in conjunction with the *platino-nasal*, and may be confluent with it for a short distance anteriorly before turning posteriorly and dipping into the vertebral column.

In one specimen the *ascending pharyngeal* was observed to have anastomosed with the *internal carotid*.

The *pulmonary* gives rise to the short *ductus Botalli* which joins the *systemic* much proximal to the junction in *Ambystoma*. After bending posteriorly the *pulmonary* gives off the *esophageal artery* slightly anterior to the origin of this same vessel in *Ambystoma*.

Francis' (1934) description of the pharyngeal arteries of *Salamandra* is almost identical with that given for *Triturus*. However, Francis finds one or two small cutaneous branches as well as the *lateral pharyngeal artery* arising from the *ductus Botalli*; these branches have not been observed in the present study.

PLETHODONTIDAE

(Fig. 6)

Fourteen injections of large and medium-sized *Plethodon glutinosus* were examined in preparation for this study.

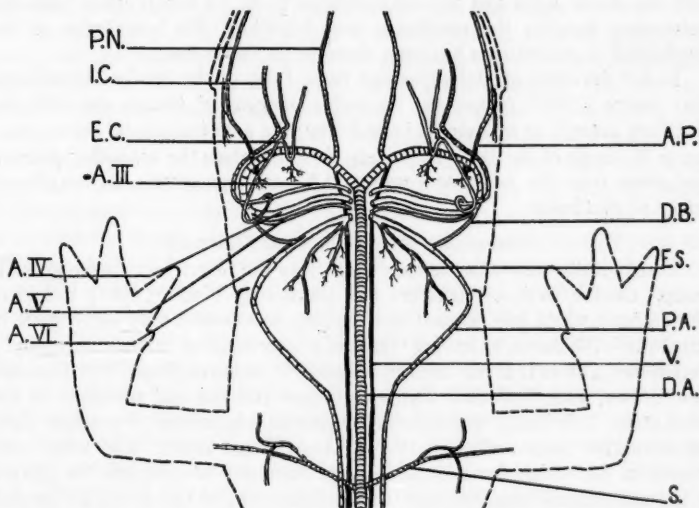


Fig. 6. *Plethodon glutinosus*. Composite drawing of plastic replicas of the anterior arteries.

Normally 4 aortic arches are present, although occasionally the 'third' arch is fused with the *systemic*.

The *carotid arch* gives off the *internal* and *external carotids* as in *Ambystoma* and *Triturus*, although no vestige of a *carotid bulb* has been observed in any specimen examined. At its origin the *external carotid* directs itself mesially, then makes a postero-lateral loop before continuing anteriorly to the lower jaw. The distribution of the *external* and *internal carotids* are as in *Ambystoma*.

The *systemic arch* passes laterally, dorsally, and then mesially and turns posteriorly before joining its mate to form the *dorsal aorta*. The *ascending*

pharyngeal in this form arises from the *systemic* slightly closer to the mid-line than in *Ambystoma* and seems to originate in a posterior direction before turning anteriorly. In well-injected specimens a branch, that immediately divides into an anterior and a posterior ramus, is seen to arise from this artery a little behind the angle of the jaw. The rami parallel the *ascending pharyngeal* superficially for a short distance. (A similar branch was noted in *Amphiuma*.) The *palatino-nasal* and *vertebral* arise as before except that the former now arises from the anterior rather than the dorsal surface of the *systemic* as in *Ambystoma*.

The '*third*' arch parallels the *systemic*, receives the *ductus Botalli*, and joins the *systemic* sooner than in *Ambystoma*.

Just after leaving the *truncus arteriosus* the *pulmonary* arch in *Plethodon* gives off 2 branches to the esophagus. It gives off the *ductus Botalli* sooner and directs itself more definitely posteriorly than in *Ambystoma*. After giving off the *ductus Botalli*, the *pulmonary* in a wide curve comes to lie parallel with the *dorsal aorta* and somewhat ventral to it. In this lungless form the *pulmonary* supplies the esophagus and intestine. No homologue of the esophageal of *Ambystoma* has been observed in *Plethodon*.

In her drawings of *Desmognathus fusca* (also of the family Plethodontidae) Seelye (1906) figures the *ascending pharyngeal* (which she calls the *maxillary artery*) as receiving a branch from the *external carotid* before passing to the angle of the jaw. The artery that she labels the *ascending pharyngeal* stems from the *pulmonary arch* and is homologous with the *esophageal artery* of *Plethodon*.

COMPARISON OF ARTERIES OF CAUDATA

Ontologically the salamanders constitute an extremely heterogeneous group. On the basis of structure and physiology Noble (1931) considers *Siren* a form which has "ceased to differentiate beyond a very early stage in larval life"; *Necturus*, as having "reached a later stage of caudate ontogeny"; *Amphiuma*, a form that has "nearly completed" metamorphosis, and *Triturus*, *Ambystoma*, and *Plethodon*, forms that have reached and remained in the adult state. It is highly desirable in the present comparison to consider these representative salamanders in the abovementioned order. For when considered in this order, few postulations are necessary to complete the picture of the ontogenesis (and, perhaps, the phylogenesis) of the aortic arches and their derivatives in the caudates.

It should be noted, however, that even though *Siren*, *Necturus*, and *Amphiuma* are sexually mature forms that in most other respects have not completed their metamorphosis, they are probably all retrogressive forms whose ancestors were fully metamorphosed and terrestrial (Noble, 1925). This phenomenon of 'larvation' is not at all uncommon among the salamanders, but has occurred independently to greater or less degree in some forms of every existing family.

Primitively the salamanders had 4 aortic arches, the *third*, *fourth*, *fifth*, and *sixth*, although this number has been or is being reduced to 3 independently in several different groups. If this reduction is correlated with lack of need for 4 arches with the loss of gills, it may be considered as additional evidence for considering *Siren* and *Necturus* as descended from terrestrial

ancestors. Among the forms considered, *Siren*, *Necturus*, and *Amphiuma* have all lost the 'third' arch, and its presence in *Ambystoma*, *Triturus*, and *Plethodon* is variable.

The gill by-passes serve to insure the body a blood supply when the gills are lost (either bitten off, as often happens, or absorbed in metamorphosis). The by-passes in the carotid arch aid in maintaining constant blood pressure in the cranial region. After metamorphosis they are retained as the carotid bulb, which moderates the great pressure developed by the ventricle of the gilled larva. The reason for the apparent absence of this structure in the Plethodontidae is uncertain.

The external carotid in the gilled forms is a ventro-mesial continuation of the first efferent, and after loss of the gills, it stems from the mesial aspect of the carotid bulb.

Passing to the systemic, it may be seen that in *Siren* and *Necturus*, gill by-passes are also present here. The afferent and efferent are continuous, however, in *Amphiuma*, *Ambystoma*, *Triturus*, and *Plethodon*.

The ascending pharyngeal artery is not present as such in *Siren*, *Necturus*, and *Amphiuma*. Instead, in these genera, a vessel, presumably homologous with the ascending pharyngeal, takes origin from the systemic and, after a distance, joins the internal carotid. This vessel is probably a persistence of the dorso-mesial continuation of the primitive third aortic arch that has remained to connect the carotid with the systemic after the mesial portion of the arch has become fused with the systemic. In *Siren* the length of this connection is only slightly greater than its diameter, but in *Necturus*, it is somewhat longer. In both of these forms, it proceeds laterally from the systemic as would be expected if the vessel were a persistence of the primitive third aortic arch. In *Amphiuma* this connection is much longer than in either of the 2 previous forms, and it closely parallels the internal carotid for a distance before anastomosing with it shortly behind the angle of the jaw. This vessel sends off a side branch in *Amphiuma* that in turn divides into an anterior and a posterior branch, which parallel the internal carotid peripherally. In *Plethodon* a similar branch has been observed to arise from the ascending pharyngeal artery. In *Siren*, *Necturus*, and *Amphiuma* the internal carotid supplies not only the cranium, as in *Ambystoma*, *Plethodon*, and *Triturus*, but also the periphery of the lower jaw. In the latter forms the ascending pharyngeal relieves the internal carotid of its duty of supplying the periphery of the lower jaw. The factors responsible for the ultimate separation of this vessel from the carotid are not immediately apparent.

In *Siren*, *Necturus*, and *Amphiuma* the vertebral arises as a posterior branch of the palatino-nasal after the latter has passed forward for a distance equal to approximately half the width of the body. In *Ambystoma* and *Plethodon* the vertebral has migrated posteriorly to assume the status of an independent branch of the systemic and passes directly posteriorly from its origin on the latter vessel. The condition of the vertebral in *Triturus* is intermediate between *Siren*, *Necturus*, and *Amphiuma* on the one hand, and in *Ambystoma* and *Plethodon* on the other. Its condition, however, is much closer to that of the latter two.

—The fifth aortic or 'third' arch, as discussed above, is always completely

lacking in *Siren*, *Necturus*, and *Amphiuma* and either partially fused with the systemic as in *Triturus*, or variable as in *Ambystoma* and *Plethodon*.

The sixth aortic or pulmonary arch is present in all forms studied, although in *Necturus* the proximal portion has been lost in correlation with the failure of the last branchial cartilage to develop (Noble, 1931). The primitive condition of the sixth arch is well exemplified in *Siren* which possesses external gills, gill by-passes, a ductus Botalli (the efferent portion of the pulmonary arch), and pulmonary artery (a posterior continuation of the efferent portion of the pulmonary arch). *Necturus* is similar to *Siren* except that no gill by-passes have been noted in *Necturus*, and the pulmonary artery stems from the fused efferents of the systemic and pulmonary arch. *Amphiuma*, *Ambystoma*, *Triturus*, and *Plethodon* have all lost the gills, hence the efferent joins directly with the afferent and continues posteriorly as the pulmonary artery. The ductus Botalli is present in all these forms except *Amphiuma*.

DISCUSSION

The vessels under consideration in this study represent the main trunks of the arterial system. These trunks lie deep within the body and, for the most part, are not associated with supplying blood to any specific muscle, bone, or gland, but to general regions of the body. Because of their function and position, these vessels are far more stable and less subject to changes brought about by slight modifications in the other body components than are the peripheral vessels.

In this study remarkably few variations have been encountered, even though they have been sought diligently, and most of those that have been found are of minor import, such as slight shifts in point of origin or junction of certain of the vessels. Since in most cases significant numbers of specimens were used and relative constancy was found among practically all specimens of each type, it is felt that error due to anomalies is reduced to a minimum. The differences that exist between the groups are constant differences, and the alterations noted appear to be the result of slow, long-range transformations, which may be correlated with major changes in the structure and in the physiological make-up of the organisms involved.

There has been demonstrated in the present study a fairly continuous series that includes the more primitive state of the pharyngeal arteries as exhibited by *Siren* and *Necturus*, the intermediate condition as found in *Amphiuma*, and the more advanced condition as found in *Ambystoma*, *Triturus*, and *Plethodon*.

While the series may be regarded as purely ontogenetic, this interpretation presents the following difficulties. (1) The fifth aortic arch is consistently absent in *Siren*, *Necturus*, and *Amphiuma*, indicating that in these forms the arch has been lost for a relatively long time. (2) *Ambystoma*, *Triturus*, and *Plethodon* all show some remnant of the fifth aortic arch, indicating that in these forms this vessel has not yet been completely lost. (3) *Siren*, *Necturus*, and *Amphiuma* all lack the ascending pharyngeal, the internal carotid supplying the periphery of the lower jaw. These forms, however, have a connection between the systemic and the internal carotid whose degree of separation from the latter vessel may be regarded as indicative of the ontogenetic state. (4) *Ambystoma*, *Triturus*, and *Plethodon* all have the ascending

pharyngeal and lack the connection between the systemic and internal carotid. (5) In *Siren*, *Necturus*, and *Amphiuma* the vertebral arises as a posterior branch of the palatino-nasal. (6) In *Ambystoma*, *Triturus*, and *Plethodon* the vertebral and palatino-nasal arise from the systemic as separate arteries (or separate immediately after arising together, as may occur in *Triturus*).

Although thorough examination of the immature forms will be necessary before final judgment can be made, present evidence indicates that the order Caudata is divisible into 2 main groups (or suborders), the first embracing the Sirenidae, Proteidae, and Amphiumidae, and the second, the Ambystomidae, Salamandridae, and Plethodontidae. Within the first group the Amphiumidae appears to have remained closest to the ancestral line, while the Sirenidae and Proteidae seem to have passed through a long independent history of degeneration. Within the second group the forms seem to be much more closely related, the Plethodontidae diverging first, and, "within the superfamily *Salamandroidea* the Ambystomidae and Salamandridae are about parallel" (Dunn, 1922).

SUMMARY

By means of a new and improved injection technique a study has been made of the aortic arches and their derivatives in representatives of six families of the order Caudata.

Descriptions are given, and a comparison is made of the condition of the arteries in the different families.

The evidence indicates that the caudate Amphibia early separated into two distinct lines, the Sirenidae, Proteidae, and Amphiumidae comprising the first line, and Ambystomidae, Salamandridae, and Plethodontidae, the second.

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Notes on Box Turtles in Colorado

By HUGO G. RODECK

THE ornate box turtle, *Terrapene ornata* (Agassiz), is abundant throughout the eastern plains area of Colorado, although many residents of the area seem not to have seen it. Under ordinary conditions this turtle is not conspicuous and it has been said that a very young animal is so rare as to be a scientific curiosity. We have collected or observed specimens from extreme northeastern to extreme southeastern Colorado, and from the Kansas state line to the foothills west of Denver and in the neighborhood of Boulder, indicating that the species is generally distributed over the entire eastern plains area of Colorado.

The three-toed box turtle, *Terrapene carolina triunguis* (Agassiz), is a probable member of the Colorado fauna. It was reported by Ellis and Henderson (1913: 117) from Wray, in northeastern Colorado. On April 14, 1947, a specimen was collected in Boulder, Colorado. That it was a former captive was indicated by a small drilled hole in the rear margin of the carapace, and there was evidence that it may have been transported to Boulder in a load of topsoil, but probably from no great distance. More complete collections may show it to be more common than present records indicate.

During the summer of 1947 there were unusual opportunities to observe ornate box turtles. A heavy rain in northeastern Colorado during July brought them out by the thousands, and literally hundreds of medium-sized specimens were killed along the highways by passing vehicles. During August numerous medium-sized turtles were found dead along the roads in the southeastern quarter of the state as well.

The question as to where they go between these sudden outbursts of abundance was perhaps partially answered by the discovery of a good-sized adult resting just within the mouth of a burrow in the sand dune area north of Campo, Baca County, Colorado, on the 19th of August. Upon being disturbed, it turned quickly about and disappeared into the burrow. Among the sand dunes along the Cimarron River a number of box turtles were found abroad just at sunrise, suggesting that they may forage at night. Although specimens are sometimes seen during the day, they probably usually go into subterranean retirement with the coming of daylight. Diurnal activity may possibly be correlated with rainy weather.

Although these turtles live in arid regions and presumably derive much of the necessary moisture from their food, they do not disdain water when it is available. Captive specimens drink deeply after having been deprived of water for some time. The mud flats of the Cimarron River bore numerous trails of turtles that had emerged from the vegetation of the banks and proceeded a hundred yards or more to the stream to drink. Some then turned around and returned the way they had come, others crossed the shallower rivulets, and still other trails indicated that the animals had willingly or otherwise entered the stream, since the trail ended at the water's edge. Experiments with captives demonstrate that they can float buoyantly and an involuntary voyage downstream probably would affect them little or not at all.

The writer, following one trail, found the turtle at the water's edge. Its head and neck were submerged, the head being not only in the water but beneath the surface of the soft mud. Active throat movements showed that the turtle was drinking.

The inclination of arid-lands turtles to imbibe large quantities of water after deprivation was illustrated by a female three-toed box turtle in captivity. After having had no water for about two weeks, it was given a dish containing approximately half a pint. It drank steadily for nearly an hour, exhausting the water in the dish, and during the latter half of the period, a constant stream of water issued from the anus.

A good-sized specimen of *ornata*, from Crowley County in southeastern Colorado, was kept as a pet by the writer in his boyhood. It fed freely on lettuce, apple and other fruits, and raw beef. With very little coaxing it was trained to assume an erect position, resting on hind feet and rear of shell, to take food from the hand, and finally came to assume this position voluntarily when begging for food.

Two recently-captured specimens of the ornate and one of the three-toed box turtles were offered grasshoppers, mealworms, and earthworms. Both species ate grasshoppers eagerly and in quantity. The two *ornata* ate mealworm adults and larvae freely, but earthworms with apparent reluctance. The *triunguis*, on the other hand, seemed greedy for the earthworms, advancing eagerly when they were offered. Both species accepted frozen bits of bird flesh.

During the 1947 field season, several live specimens of *ornata* were kept for some time in a box. After several days a considerable amount of dung accumulated in the box, and proved to consist largely of beetle remains.

These observations might permit one to propose a conjectural account of the life history of the ornate box turtle. It is possible that the young are even more subterranean than the adults. Perhaps they spend their early years in rodent or other burrows where there is a fairly abundant insect fauna. Increasing size might force them to the surface for feeding, with a daily return to a burrow for resting and protection. Heavy rains may either force them to emerge from flooded hiding places, or increased air humidity may permit their emergence in comfort and make nomadic wandering possible.

One *ornata* collected on the Cimarron River, northwestern Oklahoma, on August 19, 1947, was observed, after preservation, to have a swelling on the outside of the knee joint of the left hind leg. Examination showed this to be a subcutaneous cyst, open to the outside by a hole about 1/16th inch in diameter, and containing 15 fly larvae along with a mass of clotted blood. Specimens sent to Dr. Maurice T. James, State College of Washington, and to Dr. Curtis Sabrosky, of the United States National Museum, were identified as *Sarcophaga cistudinis* Aldrich, the larva of which was described by Greene (1925: 23). This species was described and subsequently reported from eastern turtles and appears not to have been reported for western species.

An observation made by Mr. Lowell Swenson of the Museum staff on captive specimens of the ornate and three-toed box turtles is of particular interest in emphasizing the close relationship between the two. Shortly after a feeding of earthworms on November 17, 1947, a large male specimen of *ornata* mounted a female of *triunguis*. His hind feet were firmly clasped by the

female and remained so, in spite of disturbance, for at least two hours. There was no evidence that copulation had been effected. This mating behavior between the two species was repeated on December 2, 1947. The male *ornata* involved was the largest specimen collected in 1947, having a carapace length of 5.27 inches, a plastron length of 5.31, and weighing just a pound.

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UNIVERSITY OF COLORADO MUSEUM, BOULDER, COLORADO.

Age Analysis of a Population of the Ameiurid Fish *Schilbeodes mollis* (Hermann)¹

By FRANK F. HOOPER

DURING the summer of 1946, an ecological study was made of Demming Lake, a body of water of 12.5 acres located in northwestern Minnesota near the University of Minnesota Biological Station at Itasca State Park. As a part of this investigation, quantitative studies were made of plankton, bottom fauna, rooted aquatic plants, and fish. The fish population of the lake was poisoned with derris root (rotenone) on August 15, 1946. The five species of fish present were northern pike (*Esox lucius*), common sunfish (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), tadpole madtoms (*Schilbeodes mollis*), and black bullheads (*Ameiurus melas*). A greater weight of tadpole madtoms was recovered from the lake than of any other species (88 pounds of a total of 251 pounds). The present age and growth study of this small catfish is a part of the analysis made of the fish population of this lake.

AGE ASSESSMENT

METHODS.—Since the tadpole madtom is scaleless, the scale method could not be used for age determination. Other structures, however, such as otoliths, vertebrae, and the opercular and other bones have been used successfully to assess age in fish. Walford and Mosher (1943) found that the dark, translucent bands in the otoliths of the sardine, *Sardinops caerulea*, represented

¹ Some of the data used in this paper were taken from a thesis presented to the graduate faculty of the University of Minnesota, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Also a contribution from the Department of Zoology, University of Michigan.

year-marks, and they showed that these bands could be used to determine the age of at least the younger fish of this species. Kalman (unpublished thesis, Ohio State University, 1943) found similar bands in the vertebrae of the yellow stonecat (*Noturus flavus*) and the channel catfish (*Ictalurus punctatus* = *Ictalurus lacustris punctatus*, cf. Hubbs and Lagler, 1947) which he believed represented annual markings. Moore (1947) used otoliths in the determination of age and growth of the sand flounder (*Lophopsetta aquosa*).

To attempt age determinations of *Schilbeodes*, a study was made of the vertebral centra of a series of 250 fish of all sizes. Skeletons were prepared by cutting away a part of the skin and muscle from the body and soaking the remaining carcass in a 2 per cent solution of sodium hypochlorite for approximately 24 hours. The sodium hypochlorite decreased in strength as decomposition of soft tissue took place, hence it was necessary to transfer specimens to fresh solution at 6-hour intervals. This method ordinarily provided well-cleaned skeletons that were not disarticulated. Vertebrae could be removed conveniently from any part of the vertebral column for study. Increasing the concentration of the sodium hypochlorite reduced the time necessary for cleaning. However, if decomposition was excessively rapid, poorly ossified parts were destroyed and skeletons became disarticulated.

MARKINGS OF VERTEBRAE.—The anterior and posterior faces of the centra of the entire series of skeletons were examined under a dissecting microscope. Centra of specimens between 15 and 35 mm. in standard length were all rather uniform in appearance when examined with reflected or transmitted light. The only markings on the centra of fish of this size were opaque, light dots at the center of the centra. There were no well-defined bands, as were found in centra of larger fish. Vertebrae of specimens between 43 and 77 mm.

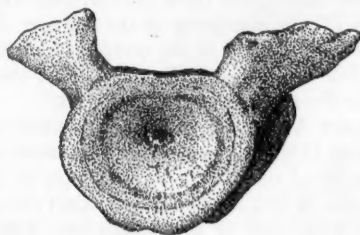


Fig. 1. Centrum of trunk vertebra of a specimen of *Schilbeodes mollis*, 75 mm. in standard length, showing a single dark band. $\times 24$.

in standard length also showed the central light dot visible in the smaller size group. Surrounding this was a poorly-defined band of darker and somewhat more translucent bone, which in turn was surrounded by a band of lighter, more opaque bone. The central light dot, together with these two bands, constituted a central core characteristic of the centra of fish of this and the larger size groups. This core is similar in appearance and position to the core or kernel noted in otoliths by Reibisch (1899). A sharply defined dark band of translucent bone surrounded this central core. This band was conspicuous and contrasted sharply with the remaining bone of the centrum. It occurred

at approximately the same relative position in the centra of all specimens of this size. Dark bands were most sharply defined in the anterior trunk vertebrae, although they could also be recognized in the posterior trunk region. Specimens greater than 85 mm. in standard length all showed a central core

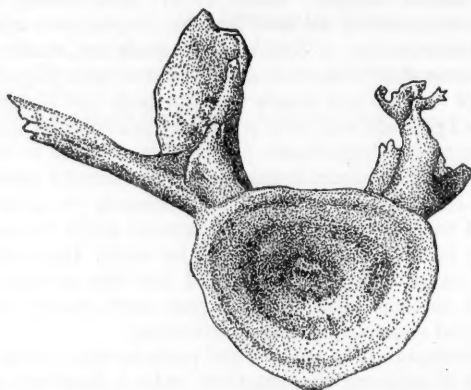


Fig. 2. Centrum of trunk vertebra of a specimen of *Schilbeodes mollis*, 92 mm. in standard length, showing two dark bands. $\times 24$.

and two dark bands alternating with two bands of light, opaque bone. Centra of fish between 78 and 85 mm. in standard length had either one or two dark bands. Vertebral markings of these fish therefore were similar to markings of either the 43-77 mm. size group or the fish over 85 mm. in standard length. Bone at the outer margin of the centra of all size groups was light and opaque. Since fish were collected in mid-August, this bone presumably was formed earlier in the summer of the same year.

LENGTH-FREQUENCY ANALYSIS.—A length-frequency analysis of a sample of 4206 specimens (Fig. 3) shows nearly identical size groups, as are indicated by the number of dark bands in the centra of the vertebrae. Fish between 15 and 35 mm. in length make up a distinct size group, trenchantly separated from the larger fish of the population. Fish between 43 and approximately 80 mm. in standard length constitute an intermediate size group. A third group of large individuals is indicated by fish greater than 85 mm. in standard length. A possible overlap between the intermediate and large size groups is suggested by the specimens between approximately 80 and 85 mm. in standard length.

The close correlation between the size groups of the length-frequency analysis and size groups indicated by the number of vertebral bands strongly points to three age groups of madtoms in the present population. The smallness and obvious immaturity of fish of the 15-35 mm. group indicate that these fish hatched during the summer in which the lake was poisoned. Vertebrae of fish of this length lacked the dark bands found in other size groups. Therefore fish of this size appear to be of age group 0 (i.e., 1946 year class). On the basis of the single band found in the vertebrae of the 43-77 mm.

group, these fish are presumed to belong to age group I (i.e., 1945 year class). Fish greater than 85 mm. in standard length are believed to be of age group II (i.e., 1944 year class) because they all showed a second vertebral band. Examination was made of the vertebrae of all fish between 78 and 85 mm. in standard length occurring in the sample of the population analyzed. Fish possessing a single dark vertebral band were included with age group I, while fish with 2 bands were included with age group II.

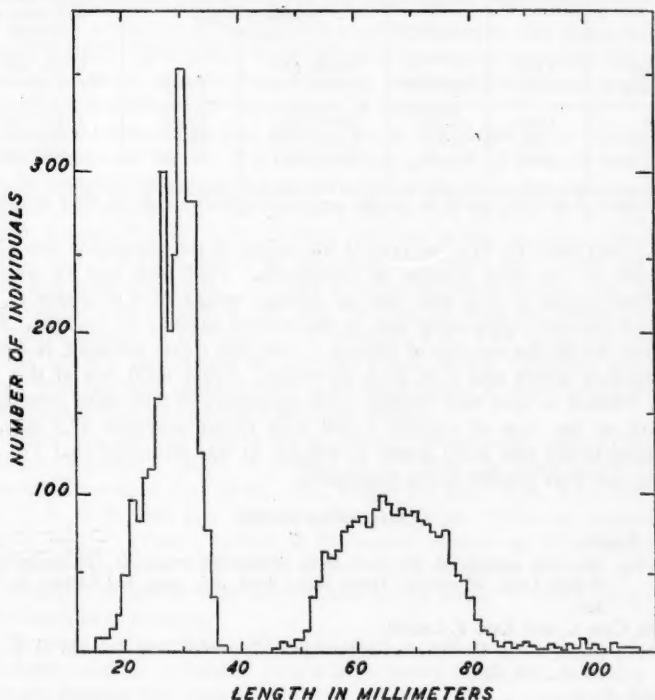


Fig. 3. Standard-length frequency diagram for *Schilbeodes mollis* population.

Certain requirements for age assessment by annual markings (cf. Hile, 1941) are met remarkably well by the sample of madtoms surveyed: (1) regularity of increase in number of vertebral bands is accompanied by an increase in the size of fish, thus indicating that the bands are added systematically as growth proceeds; (2) modes in the length-frequency distribution coincide with the modal lengths of age groups based upon the number of vertebral bands. Therefore I am led to believe that the age groups of this population, as determined by a study of the vertebral centra, are valid.

CHARACTERISTICS OF AGE GROUPS

It was estimated that approximately 16,770 madtoms were present in the lake at the time of poisoning. This estimate is based upon counts of fish re-

moved from the lake and counts of fish remaining in the lake that could not be efficiently recovered. Certain characteristics of the three size and age groups of the sample of the population analyzed are given in Table I. The 1945 year class appears to be a predominant year class of the population.

TABLE I
CHARACTERISTICS OF AGE GROUPS IN A POPULATION OF *Schilbeodes mollis*, AS DETERMINED
BY ANALYSIS OF GROWTH BANDS ON VERTEBRAE

Age group	Year class	Number*	Standard length in mm.		Wet weight in grams
			Mean, and standard error	Range	Mean, and standard error
O	1946	2176	26.4 ± .077	15-35	0.32 ± .004
I	1945	1978	61.6 ± .170	43-85	4.16 ± .054
II	1944	52	89.1 ± .927	78-104	16.32 ± .516

*Number of specimens present in analyzed sample (approximately $\frac{1}{4}$ of the entire population).

This group made up 81.6 per cent of the weight of the population and 47.07 per cent of the total number of individuals. These fish had an average standard length of 61.6 mm. and an average weight of 4.16 grams at the time of capture (apparently late in the second summer of growth). Fish hatched during the summer of capture (1946 year class) averaged 26.4 mm. in standard length and 0.35 gram in weight. About 8600 fish of this age were believed to have been present. Fish apparently in their third summer of growth at the time of capture (1944 year class) averaged 89.1 mm. in standard length and 16.32 grams in weight. It was estimated that 270 fish of this age were present in the population.

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Natural History Notes on Tiger Sharks, *Galeocerdo tigrinus*, Caught at Key West, Florida, with Emphasis on Food and Feeding Habits

By E. W. GUDGER

INTRODUCTION

THE genus *Galeocerdo* belongs to the great family Carchariidae, the gray sharks. A number of species have been attributed to this genus, but the present tendency is to reduce these names to synonymy and make the genus monotypic—*Galeocerdo arcticus*. However, in this article the names used by the authors quoted will for convenience be retained.

SIZE ATTAINED.—The tiger shark is one of the largest of the sharks that inhabit our coastal waters. It is said to attain a length of 20 to 30 feet. This may be true, but in this search no record of such giants has come to light. I cannot find anyone who has measured one as long as even 20 ft. My own largest measured 11 ft., 6 in. Stewart Springer writes (personal communication) that in Florida waters he has "measured many over 12 ft., one over 13 ft. and none over 14 ft." He says that his fishermen friends have spoken of specimens over 16 and 18 feet long, but none of them had actually measured these giants. A specimen of *G. tigrinus* 15 ft., 2 in. long, reported by Burton (1941), was caught off the Charleston (South Carolina) jetties in 1940. This big male is the largest tiger shark known to have been captured in Western Atlantic or in Gulf-Caribbean waters.

Beebe and Tee-Van (1941) say of the tiger shark in the eastern Tropical Pacific—"Reaches a length of at least 20 ft." But the three largest specimens they measured were 10 ft., 1 in., weight 366 lbs.; 10 ft., 6 in., 505 lbs., and 12 ft., 9 in., 780 lbs. However, Whitley in his "Fishes of Australia—Part I, Sharks" (1940), records as *Galeocerdo rayneri* an individual taken in 1936 at Maroubra, New South Wales, which measured 15 ft., 6 in. This is the largest measured tiger shark taken in any ocean, of which record has been found in this search.

PHYSICAL CHARACTERS.—The tiger shark is well named—for its physical appearance and for its habits. It is a large, heavy shark, and its bluish-gray sides are marked with dark vertical bars or stripes like a tiger, as is faintly shown in Plate I. Sometimes the sides have short bars and these are often set staggered, whence probably comes the West Indian name "leopard shark." From the figure it may be noted that *Galeocerdo* is very heavily built forward of dorsal fin I. It has a large bluntly rounded head, wider than deep, with wide heavy jaws having a large vertical gape. Both jaws are beset with many large, serrate, sickle-shaped or notched teeth—the hooks on the teeth all pointing outward right and left (Fig. 2). No explanation has been found for the peculiar shape of the teeth, but I suggest that they function with a shearing bite. These large jaws and saw-edged teeth are plainly adapted for chopping the prey into large fragments, which are swallowed whole. Of sharks whose teeth are known to me, only *Carcharodon*, the great white shark, has better chopping teeth.

HABITS.—In its habits the tiger shark lives up to its name, being fearless,

voracious, and omnivorous. Like all large and fierce sharks it is accredited with being a maneater, but no evidence has been found for such a habit in our waters. That even the tiger shark would attack a live unwounded man is doubtful—unless the shark were wounded, angry, cornered or ravenous. That it would lay hold of, chop up and swallow parts of a dead human body, I have no doubt, nor will the reader of this article.

From this point on attention will be directed to the food and feeding habits of the ever hungry *Galeocerdo tigrinus*. However, other matters, particularly size and various behavior data, will be noted for the individual sharks studied, since these things are part of the general natural history picture. These notes are made from my studies on six large specimens captured and dissected at Key West, Florida.

SPECIMENS STUDIED

I spent four seasons (1912–1915) at the Marine Laboratory of the Carnegie Institution of Washington, at the Dry Tortugas, last far-flung western outliers of the Great Florida Reef. Tiger sharks were occasionally seen here, but not in the great concentration as at Slaughterhouse Point on the southwest part of Key West Island. Here, attracted by the rejectamenta of the municipal abattoir, one could at almost any time see two or three, or a flock of tigers cruising around, seeking what they might devour, and nearly every time that our boat, the "Dohrn," went from Tortugas to Key West for mail and supplies, I went along for a tiger-fishing foray. From my notes the following data as to stomach contents and other interesting things have been excerpted.

Tiger Shark No. I, Key West, July 9, 1912.—When our launch reached Slaughterhouse Point on the ocean side of Key West Island, the waterscape presented an amazing sight to my unaccustomed eyes. Half a dozen big tiger sharks were sculling around and three were wrestling with some beef offal. We threw out a shark hook baited with stingray fin (prized bait for sharks). A big tiger made two charges and carried off the bait each time, the third time it was hooked. This shark put up a hard fight but was finally secured, killed, and for dissection was towed to Curry's dock on the other side of Key West Island, 4 miles away. There a line was secured around the small of the tail and rove through a pulley in an unloading crane. All the loafers on the dock tailed onto the line and the big shark slowly came up. When the head was lifted clear of the water a lot of food material poured out of the mouth, presumably due to a relaxation of the sphincter muscle of the gullet.

This tiger shark was a female, 10 ft., 10 in. long from tip of snout to tip of tail; her girth in front of dorsal fin I was 5 ft., 3.5 in., and the width of mouth straight across from angle to angle of the jaws was 1 ft., 4 in. Tiger sharks have large digestive tracts. This one's measured 6 ft., 6.5 in., from front edge of mouth to vent.

This prize stomach (unfortunately not measured), after losing a lot of its contents, as noted above, still contained a small washtub full of yellow liquid material from which I gathered fish bones, grass, feathers and bones of one or more marine birds, fragments of green turtle shell, old cans, a dozen vertebrae of a cow, and the skull of a dehorned cow with the lower jaw lacking. This

cow's head undoubtedly had been discarded from the slaughterhouse. The flesh had been digested and the outer hard smooth layer of the skull bones everywhere had been dissolved leaving only the inner cellular or cancellous material. This in turn was so soft that one could dent it with a finger. The digestive juices of a shark's stomach (presumably chiefly hydrochloric acid) are very concentrated. When working in a tiger shark's stomach, frequent washings of the hands are necessary to keep the outer surface of the skin from being eaten away.

Tiger Shark No. II.—June 20, 1913, was spent at Slaughterhouse Point trying to inveigle a big tiger into taking a hook well encased in a large piece of eagle ray. The effort proved fruitless, so we decided to try the harpoon as a last resort—a harpooned shark being much more difficult to subdue than a hooked one.

The harpooner took his stand on the bow of the launch and I steered him up on the big tiger for a successful throw. The harpoon held, but being caught in the flank of the swimming shark we had poor control of our prey. By hauling on the line, we tried to get the fish alongside the boat to put a line around its tail. But time after time it broke away, taking the line out in spite of our efforts. It towed us into deeper water, but was plainly weakened by the fighting. Presently the maddened shark came up by the bow of the launch and gripped the stem with its jaws—the teeth tearing the wood and leaving scars. Finally, we got it alongside the launch, and, when its tail lashed inward over the gunwale of the launch, I laid hold of the fin with both hands while the engineer got a line around the small of the tail. This was secured to the bitts at the stern of the launch and we started for the dock on the other side of the island. The bucking and rolling of the big shark brought our speed down almost to a snail's pace.

At the dock, we found that, instead of being drowned by this tail-foremost progression, as is generally the case, the big fish was still alive. This complicated the task of getting our prey up on the floor of the dock, but it was finally done and the shark was killed and measured. This was our largest tiger—11 ft., 6 in., from tip to tip. From corner to corner of mouth around over the top of the head was 2 ft., 10.5 in. The girth at front base of dorsal I was 5 ft., 3 in. The length of the alimentary canal from tip of lower jaw to cloaca was 6 ft., 4 in.

The stomach contents of this big female were disappointing—consisting only of some bones (of cattle, apparently), some turtle scutes, and the feathers and legs of a marine bird. Possibly some food had been disgorged in her struggle on the way to the dock.

Tiger Shark No. III.—Harpooned off Slaughterhouse Point on July 10, 1914. After a hard fight it was killed and towed into the dock for measurements and dissection. This fish, also a female, measured 10 ft., 6 in., over all. The head and forepart of her body were very large. The girth around her head at the angle of the jaw was 3 ft., 9 in.; and of the body at the anterior edge of dorsal I was 4 ft., 9 in. The length from tip of lower jaw to vent was 6 ft., 3 in. The spread of the caudal fin was 2 ft., 6 in. On the sides of body were three rows of nearly square bars set staggered (leopard shark?).

The contents of her stomach comprised some plates of the shell of a green turtle; and the upper and lower horny jaws of a turtle (the jaw bones

were gone, probably dissolved by the acid of the digestive juice). There were also three tin cans, a quantity of feathers, a piece of rope, and a small fish-hook with a 4-foot wire snood. All these things were immersed in a large quantity of bilious-green fluid.

Tiger Shark No. IV.—Taken with a hook off Fort Taylor, Key West Island, June 15, 1915. This fish, like the others, put up a hard fight, but being hooked was fairly readily subdued, secured by a line around the small of the tail and brought to the dock. This female shark measured over curves 11 ft., 4 in., and between perpendiculars 10 ft., 9 in. The measure across the head, from angle to angle of jaws, was 2 ft., 4 in., and the girth just behind dorsal I was 5 ft., 6 in.

For stomach contents, this was my most prized tiger shark. The contents included the skeleton of a horse's head (lacking the lower jaw) with some vertebrae attached—length 22 in., depth 12 in., width 7.5 in.; and two hoofs with basal foot and other middle finger bones attached. There were also several green turtle scutes, several opercula from big conchs, and a piece of tile. The outer hard smooth surface of the horse's skull had all been corroded away leaving the cancellous material about the consistency of sponge-rubber. The horny material (scutes and opercula) were intact. How this large shark probably got this horse's head is discussed later. The great girth of this big shark was undoubtedly due to these stomach contents.

Tiger Shark No. V.—A female, taken at Key West on June 17, 1915. This shark tried our baited hook (lying on the bottom) five times before she was fairly hooked. She was unusually large forward and the head was very large, squarish and blunt. The lower jaw was noted as heavy and bulldog-like. The length of the shark between perpendiculars was 10 ft. The lower jaw measured along and around the curve, 1 ft., 7.5 in. The vertical gape of the mouth was 1 ft. The girth, over and around the head at the angles of the jaws, was 3 ft., 5 in., and at dorsal fin I was 5 ft.

The stomach was proportional in size to the head and jaws. It contained six horseshoe crabs varying from 4.5 to 6 in. over the base of the horseshoe; one horse's hoof with attached shoe, but all the bones of the foot were gone. Also present were numbers of loggerhead and green turtle scutes; 13 turtle eggshells; and a lot of miscellaneous material of which fibrous worm tubes were easily identifiable. These contents surely make a poor diet. Possibly hunger explains the five tries at the hook before the shark was secured.

Tiger Shark No. VI.—Taken in Northwest Channel, Key West, also on June 17, 1915. It was a male, very dark in color, and it put up a hard fight when hooked. It must have been a great fighter out in the open. It had lost a bite-sized piece of the backside of the tip of the left pectoral fin. The point of dorsal II was gone, as was about half of the upper lobe of the caudal. However, his length, even with a mutilated tail fin, was 9 ft., 2 in. The girth around head at angle of jaws was 4 ft. and in front of dorsal I, 4 ft., 8 in.

The stomach contained the intact head of a large jewfish hung overboard as "chum," a lot of feathers of some marine bird, and some kernels of wheat and corn. This shark must have been ravenous for it took the baited hook in so deeply, and this was caught so far back in the hyoid region, that it had to be cut out from the outside and not got out through the mouth.

It is interesting, but it must be merely fortuitous, that five out of six Key West fish were females.

At the Tortugas, the tiger shark seems rare. I do not recall seeing any in the open, although they were known to be there. The atoll is composed of a group of small islands roughly enclosing a lagoon. Here the sharks are strictly "on their own" so far as food is concerned. This they must find in the fishes and turtles and marine birds (on the surface of the water) that they can catch. As for the fishes, there are few there that go in schools, and the agile scattered individuals can dodge among the coral growths and elude the sharks. Under these conditions, the Tortugas sharks are probably hungry most of the time. I put out shark hooks at intervals but only caught one tiger in my four seasons there. This specimen (a male) had an empty stomach, but since his behavior was very interesting, and since he is the original of Plate I, his capture will be described.

This specimen was taken on a shark hook baited with a fragment of spotted stingray hung off the stern of our launch on the evening of May 30, 1913. When at 4:30 next morning I went to see what had been hooked, a male tiger was found to have swallowed deeply bait and hook. In his efforts to escape he had carried the line from the hook forward to, and had wrapped it several times around, the anchor chain. Furthermore, in his flurries he had contrived to get the anchor chain in a half-hitch around his tail. Seeing that he was securely anchored fore and aft, I went off to breakfast. Later with the help of three men the anchor was pulled up and the tail of the shark freed from the half-hitch. Next we cut and freed the line of the hook from the anchor chain. Then all hands tailed onto the line and dragged the shark ashore where it was killed by pounding its nose with a hammer—the easiest way to kill a shark. A line was then put around his tail and he was hoisted up by a davit on the dock (Pl. I) to be photographed. Later the shark was let down, photographed on the sand, measured and dissected.

This male tiger measured 10 ft., 4 in., over all and, hanging as Plate I shows, had a girth behind the pectoral fins of 4 ft., 6.5 in. The circuit around the outer surface of the lower jaw was 1 ft., 7 in. When hung up, the oesophagus partly everted and brought out (until caught by the teeth) some feathers of a sea bird (presumably engulfed at the surface of the sea) and among them a ham bone—probably thrown overboard by our cook. This indicates the scarcity of shark food at Tortugas. This shark was apparently ravenous and this may largely account for his extraordinary voracity in swallowing the hook and bait so deeply, and possibly also for his great activity.

A final incident may be given, illustrating the voracity and power of large tiger sharks and explaining the source of the content of one stomach noted.

One afternoon, I stood on the dock of the Mallory Line Steamship Company in Key West, when a dead horse came drifting out with the tide and with it a horde of hungry sharks in close attendance. Fastened to each leg was a big tiger, and the four were bucking, charging and rearing, each trying

to tear off the leg of its attachment. Along with these big sharks were many smaller ones—seemingly as many as could find folds of skin in which to sink their teeth. But the horse had been dead only a short time and bacteria had not had time to disintegrate the skin tissues and hence the sharks were not able to tear it apart. And so horse and sharks drifted out to sea, but I suspect that, could some of these sharks have been captured some days later, the head and several hoofs would have been found in their stomachs.

This typifies the way large dead animals were disposed of at Key West in the old days—and possibly are today. They were dragged down into the water, and were possibly towed out into the channel. All this with the assurance that the body would be carried out of the harbor by the tide and would be entombed by and in the sharks.

HOW CAN SUCH LARGE OBJECTS BE SWALLOWED?

It must amaze the reader to learn that the skull of a dehorned cow was found in the stomach of a 10-ft., 10-in. tiger. It seems almost impossible that such could have been taken in whole. But the shark's mouth was 1 ft., 4 in. wide, straight across from angle to angle, and her girth in front of dorsal fin I was 5 ft., 3.5 in. Quite possibly this great girth was in part due to the presence of this cow's skull in the stomach. Furthermore, in shark No. IV, a 10-ft., 9-in. female, was found a large horse's skull with some cervical vertebrae. This shark measured over the head from angle to angle of jaws, 2 ft., 4 in., and her girth in front of dorsal I was 4 ft., 9 in. It must be understood that the crania of both cow and horse were swallowed, presumably as heads—probably with the lower jaws gone. But even though the heads may have been partly decayed (enough to loosen the jaws), they must have been at least partially covered with flesh. Unfortunately no camera was at hand wherewith to photograph the skulls. When allowed to dry, being without bony structure, they became too distorted to be of value as specimens.

When one considers the size of the horse's skull and the comparable one of the dehorned cow, one may well wonder how they were taken through the mouths of sharks of the sizes noted. How is it possible for these sharks to swallow such large objects? An answer will be found in the next section.

THE JAW MECHANISM OF SWALLOWING IN THE TIGER SHARK

It must be understood that, by reason of its structure, the mouth and jaws of a tiger shark are capable of very considerable distension. The upper and lower jaws have a joint at each corner of the mouth made both strong and flexible by large elastic ligaments extending across from the basal part of one jaw to the other. Then each jaw, upper and lower, is made up of two halves joined at the symphysis or middle point of each jaw by a thin symphyseal ligament making a kind of hinge joint. Thus the shark can drop its lower jaw for a great vertical gape of the mouth, and at the same time can widen its mouth in a right-left plane at the angle of the jaws by bringing these somewhat forward as well as outward. This gives a large tiger the ability to swallow such large objects as the heads of the cow and horse described above. These matters will be made clear in the next paragraph and by a study of Figure 3.



Fig. 1. A 10-ft., 4-in. tiger shark hung up by the tail at Tortugas, Florida. The man standing alongside is 6 ft. tall. Note the markings on the shark, its heavy build forward, and some feathers protruding from the mouth. Photograph by Alfred G. Mayor.

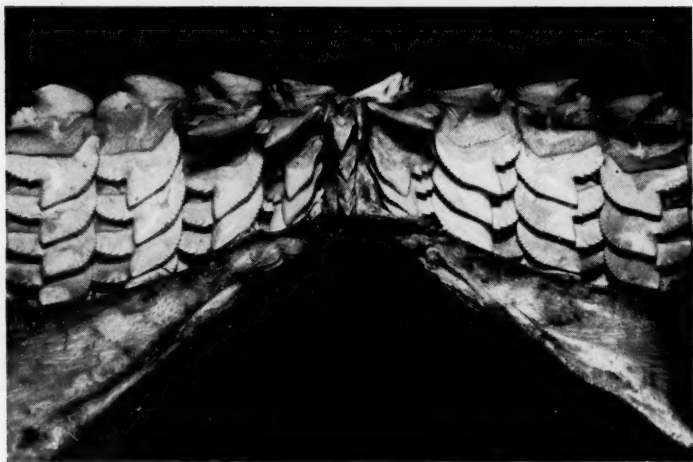


Fig. 2. The central part of the lower jaw of a 10-ft., 10-in. tiger shark seen from behind. Note the small pointed teeth at the symphysis of the halves of the jaw. On either side are rows from back to front of large sickle-shaped serrate teeth pointing left and right respectively. The upper (inner) edge of each tooth is finely serrate, the lower (outer) edge is coarsely serrate. These curious sickle-shaped teeth, here seen in natural size, seem specialized for a shearing bite. AMNH photograph.

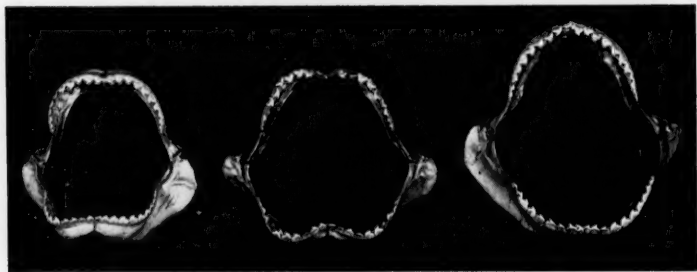


Fig. 3. Three sets of dried jaws of the tiger shark. That on the left is from a shark 10 ft., 10 in. long. Its inside measurements are: horizontal, 12.5 in.; vertical, 14 in. The jaws in the center are from a shark 10 ft., 9 in. long. They measure (inside) horizontal, 17 in.; vertical, 14.75 in. The jaws on the right are from a shark of unknown length (13-14 ft. ?). They measure (inside) horizontal, 17 in.; vertical, 20.5 in. They pass over a man with a 40 in. waist and weighing 166 lbs. AMNH photograph.

There are before me as I write two pairs of cured and dried tiger shark jaws from Key West. The first (shown at the left in Fig. 3) is of my No. I shark. The horizontal gape measures 12.5 inches, the vertical 14 in. It is possible that in drying these jaws too short a stick was used across the mouth and hence that the horizontal gape measure is probably slightly below normal. These jaws are from the female shark in whose stomach was found, in addition to various small stuff, the skull of a dehorned cow. From the measurements of the dried jaws, it is clear that the shark had had no difficulty in swallowing the cow's head.

No. II pair (in the center) are also from Key West, and are the jaws of shark No. V. The horizontal measure of the jaws is 17 in., and the vertical is 14.75 in. These jaws present a very symmetrical appearance. They will pass easily over the bodies of normal-sized young men and women, as I have proved by experiment. With these great jaws, this large female tiger shark had little or no difficulty in taking in the horse's head with the attached vertebrae—even though this was 12 inches deep by 7.5 wide.

Mr. Stewart Springer has presented to the American Museum the largest pair of tiger shark jaws that I have even seen. The shark was taken at Englewood, on the west coast of Florida. Unfortunately no measurements of it are available, but it must have been 13 or 14 ft. long. These jaws are shown on the right of Figure 3. Their measurements are: vertical, 20.5 in.; and horizontal, 17 in. By turning the vertical line of these jaws in the plane of my shoulders and hips, with coat off, I can pass through them. My waist line measure is 40 in., and my weight is 166 pounds!

When one considers these huge jaws and recalls the girth of sharks I and V—at the back of the head and in front of dorsal I—then one is prepared to understand that mouth, gullet and stomach in these tiger sharks form one continuous tube and this is probably of very uniform caliber. The gullet when at rest may be somewhat smaller than mouth and stomach, but if so it is most surely distensible—the heads of the cow and horse passed through the gullets of their respective swallowers. The stomach, naturally large, is capable of great distension. The heads of cow and horse were but a part of the contents of each stomach.

Of these conglomerate contents one may surely say that: All is Grist that Comes to the Tiger Shark's Mouth and Stomach.

THE FINAL DISPOSAL OF THE INDIGESTIBLE CONTENTS OF THE TIGER SHARK'S STOMACH

As has been noted, the digestive juices of the tiger shark's stomach are abundant and powerful. One man speaks of this fluid as "burning like fire." Those objects which are nutritious and digestible are very quickly disposed of by these abundant juices and hence the tiger shark is probably always hungry. But the reader is asking—"What does the tiger shark do with all the indigestible things?" The answer is not easy. Of the metallic things, the hydrochloric acid would probably eventually dissolve the iron of the tin cans, and also the iron horseshoe and the fishhook and snood. But the hoofs, the turtle scutes and horny jaws, and the remnants of the skulls of horse and cow are insoluble in hydrochloric acid, and so probably are the turtle egg

shells, the skeletons of the king crabs, the flexible worm tubes, the bird feathers, and the conchs' opercula. These and such inorganic things as the piece of tiling are simply ballast. Then if such objects should continue to accumulate, the very mass of them would be a serious matter for the shark.

The shark must be able to rid itself of these indigestibles or it would surely die. A person used to noting the passing of coarse indigestible non-food materials through the alimentary canals of mammals, might think that the smaller things if much broken up might pass down the hinder digestive tract and out at the vent of the tiger shark. But in sharks, the hinder or large intestine is filled with a close-fitting spiral valve through which can pass only finely comminuted semi-liquid feces.

The stomachs of these non-discriminating tiger sharks are filled with all sorts of small and large foreign bodies. If the shark cannot rid itself of these it will presently be overloaded and will die—and it would seem of indigestion. But so far as published records go, no one has ever found a dead tiger shark with an overloaded stomach. All such overloaded sharks when captured have been very much alive, as has been recorded herein for my six specimens. These large indigestible bodies must come out where they went in—through the mouth. There is no other exit. And, that sharks so relieve themselves, Radcliffe (1916: 238), writing of a school of tigers around a vessel in the harbor of Beaufort, North Carolina, and of the capture of several, noted that this shark has to some extent at least the power of fetching up some of the contents of the stomach. He states that: "At the time of capture one of the [tiger]sharks regurgitated a rat, another a small shark about 61 cm. [c. 24 in.] long." So far as I know this is the first published account of regurgitation by a shark. In Figure 1 is shown a tiger shark, hanging up by the tail, with the mouth filled with feathers in which a ham bone was entangled. The shark was recently dead and when hung up by the tail, the relaxed muscles in the wall of the oesophagus allowed some slight eversion in the gullet of this shark. Concerning this matter Stewart Springer writes (personal communication):

I have never seen a [live] tiger shark in the act of everting the stomach . . . I have seen tiger sharks, which were more or less dead, with the stomach inside out and projecting more or less beyond the jaws. I have never seriously examined the structure of the anterior part of the tiger shark's digestive tract but I think that there is a sphincter muscle at a point near the beginning of the gastric mucosa. There is probably little difference in actual size (stretch) of the gullet and stomach. Consequently, I think that if the sphincter was relaxed and the body cavity was squeezed by muscular contraction [of the body walls] the entire stomach contents would be pushed out very easily. What I mean is that I judge it would be physically possible for the shark to disgorge without actual eversion of the stomach itself.

This seems to me to be an entirely sound conjecture and I so adopt it. Five of my sharks, dragged tail-foremost from the place of capture 1 to 4 miles to the dock where they were dissected, were dead on arrival and may well have lost some of their contents en route. This seems probably true also of my tiger No. II, which was dragged around the island to the dock, rearing, bucking and rolling but arriving alive. It seems not improbable that the above conjecture explains why this big female had a practically empty stomach on dissection.

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An Approximate Formula for Stating Taxonomically Significant Proportions of Fishes with Reference to Growth Changes

BY A. E. PARR

THE common practice in defining a species of fish is to give fixed ranges for the proportions between its various parts, or between its parts and the whole. This method has proved fairly adequate for the treatment of shallow water species. The reasons may be several. Among shallow water forms the number of specimens available is usually sufficient to permit the selection of an adult individual as a basis for the definition of the species. As a consequence of the immediate or prospective availability of more adequate material, there has further been less need, or temptation, to introduce new species of shallow water fishes on the basis of immature specimens, and a tradition of avoidance of such a practice has become fairly general. Finally, there does seem to be some indication that morphological differentiation beyond what is often referred to as postlarval, or obviously juvenile, stages may be generally less protracted among shallow water forms than among deep-sea fishes, making a relatively small, shallow water specimen more representative of the final proportions of the full grown individual than is commonly the case among deep-sea inhabitants. This last factor, however, is only an indicated possibility, which the writer is not ready to offer as an actual conclusion, or valid generalization, until much more data are available.

Although the customary practice may thus be fairly satisfactory for shallow water material, it is definitely totally inadequate for the taxonomic identification of deep-sea species. In view of the scarcity of material, the description of new species on the basis of small specimens, without immediate

possession or reasonable prospects of series for comparison, has been more of a necessity than a temptation for those whose duty it has been to give an account of deep-sea collections. As a result we commonly find that the records of many nominal species, allegedly distinguished by their proportions, are equally distinguished by very great differences in the size of the specimens on which they are based.

Deep-sea collections have now grown to the point where sufficient comparative material is available for approximate evaluation of growth-changes in the most general terms, without being sufficient for the refined mathematical treatment already applied to various shallow water species in such studies as those made by Ford¹ on the herring, and in similar investigations. Nor is the material sufficient to remove, at least for the writer, the difficulty of making a reasonable guess from an inspection of the specimen as to whether or not it may be assumed to be approximately representative of the full-grown proportions. As already suggested, this difficulty seems much greater in dealing with deep-sea forms than in the study of shallow water material.

A practical, but simple, method of taking growth changes into account, without resort to refinements or warranted by the extent of the material, is therefore needed. An answer to this need may be found in the use of rectilinear functions to express the regression of relative proportions upon the absolute length of the specimens.

In order to develop the most practical formulas, and to test the permissibility of the proposed method of expression, it is first necessary to study the proper use of rectilinear functions to describe the contents of the scatter diagrams customarily used in order to evaluate, for taxonomic comparisons, the significance of changes due to growth. If the expressions thus developed are found to provide a practical and complete statement of the data, it is obvious that the use of these functions in the definition of the species would form a very valuable addition to taxonomic diagnosis. Our next step will be then to consider whether the same expressions can not also be used for an extension of taxonomic practice in the study of interspecific relationships, and in the initial comparison of otherwise not comparable characteristics of scarce specimens of unequal size.

APPLICATION TO CUSTOMARY TAXONOMIC COMPARISONS

The relative diameter of the eyes and the relative length of the heads in *Platytrichtes apus* apparently represent illustrations of differential growth continuing to maximum recorded size, as shown in Figures 1A and 1B. In the customary terms, the length of the head would be described as 25-35 per cent of length without caudal (hereafter referred to simply as the standard length, or L), giving a range of 9 per cent of L, and the diameter of the eye would be given as 8.5-12 per cent of L, with a range of 3.5 per cent of L. It is obvious that the median values of these ranges bear no relationship to any true averages, and the figures do not serve to establish any norms for the species, against which individual deviations can be measured. A couple of straight lines, fitted by eye, are therefore introduced into the diagrams, and the function for each line is determined. We observe that the line fitting the relative

¹ See: Journ. Mar. Biol. Assoc., 16 (N.S.); 723-752.

sizes of the eyes indicates a value of 13 per cent at 20 mm. L, and a value of 10 per cent at 120 mm. L, or a reduction of 3 per cent of L per 100 mm. L, i.e., a slope, or coefficient, of $\frac{3}{100}$, which gives the following equation, with L expressed in mm.:

$$\text{Diam. eye, } P. \text{ apus, per cent of } L = K - \frac{3}{100}L \quad (1)$$

At 120 mm. L the diameter of the eye is 10 per cent of L. Inserting in (1) and solving for the constant, K, we get:

$$10 = K - \frac{3}{100} \cdot 120 \quad K = 13.6$$

which gives the following expression for the diameter of the eye in *Platytroctes apus*:

$$\text{Diameter eye, } P. \text{ apus, per cent of } L: \left(13.6 - \frac{3}{100}L \right) \quad (2)$$

This expression gives us a true norm for the species, in first approximation, and an inspection of the diagram shows that none of the recorded proportions deviate by more than 1 per cent of L from the regression line, giving a total range of only 2 per cent around the norm, instead of the 3.5 per cent range in the customary expression. This empirically determined range of variations should be added to the expression used in (2) in the form of a superscript. For reasons which will become clearer in our next example, it is also desirable to add, as a subscript, the range of standard lengths over which the material has been found to fit the expression used. The full expression of (2) thus becomes

$$\text{Diam. eye, } P. \text{ apus, per cent of } L: \left(13.6 - \frac{3}{100}L \right)^{\pm 1}_{30-150 \text{ mm.}} \quad (3)$$

which means that between about 30 and about 150 mm. standard length the term $\left(13.6 - \frac{3}{100}L \right)$ has been found to express the diameter of the eye in per cent of L with errors not exceeding 1 per cent of L. In the same way we obtain (see Fig. 1B):

$$\text{Length of head, } P. \text{ apus : per cent of } L: \left(36 - \frac{1}{20}L \right)^{\pm 3}_{30-150}$$

which gives a range of variations around the norm of only 6 per cent of L, instead of a range of 9 per cent of L in the customary expression.

In our next examples (Figs. 1C and 1D), taken from the measurements of *Xenodermichthys copei*, it seems obvious that we are dealing with a species in which the proportions of eye and head relative to L become fixed at about 120 mm. standard length, while the changes in these proportions between 20 and 120 mm. L can be very closely fitted by straight lines. It therefore becomes necessary to add another term to the expressions used for the corresponding proportions in *Platytroctes*. After determining the slope between 20 and 120 mm. L, as previously explained, we therefore write:

$$\text{Diam. eye, } X. \text{ copei} : \left(11.5 - \frac{1}{30}L\right) \xrightarrow[20-120]{\begin{smallmatrix} +3 \\ -1 \end{smallmatrix}} \xrightarrow[120]{\begin{smallmatrix} +2 \\ -1 \end{smallmatrix}} 7.5 \text{ per cent of } L \quad (4)$$

$$\text{Head, } X. \text{ copei} \left(31 - \frac{1}{20}L\right) \xrightarrow[20-120]{\begin{smallmatrix} +1.5 \\ -2.5 \end{smallmatrix}} \xrightarrow[120]{\begin{smallmatrix} +1.5 \\ -1.5(3.5) \end{smallmatrix}} 25 \text{ per cent of } L \quad (5)$$

indicating that above 120 mm. L the proportions become constant around the values indicated.

In the first term of (4) different ranges of positive and of negative deviations from the norm are indicated on the basis of the data. Whether or not there actually is an asymmetric distribution of variations in this particular case, such asymmetries are often to be expected. When the scatter diagram shows isolated greater deviations on one side of the norm than on the other, it therefore seems best to indicate this as a simple statement of empirical fact, to be modified when more data become available, instead of assigning to *both* sides the maximum deviation on one side, contrary to the actual observations.

In our fifth example, dealing with the maximum relative body depth of *Platytröctes apus* (Fig. 1E), we finally have an example of a positive slope, which at the same time provides a good illustration of the shortcomings of the rectilinear method of presentation in the instances in which a more accurately fitted curve of higher power would show a relatively short radius of curvature over a rather wide angle. But even in the case illustrated, which undoubtedly represents a very unusual extreme, the usefulness of the rectilinear approximation is not destroyed, and it is seriously minimized only over a short range.² In most other growth curves the discrepancy will be much less than in this illustration.

Granting that three sets of measurements, of specimens less than 80 mm. long, do not give much assurance of accuracy, even in first approximation, it will be seen from Figure 1E that the following functions give a fair expression for the data available,³ with a reasonable integration between the records of the larger and the smaller specimens, as more clearly shown by the curve.

$$\text{Body depth, } P. \text{ apus} : \left(7.5 + \frac{2}{5}L\right) \xrightarrow[30-80]{\begin{smallmatrix} +3 \\ -3.5 \end{smallmatrix}} \xrightarrow[80]{\begin{smallmatrix} +3 \\ -3.5 \end{smallmatrix}} 39.5$$

While the expressions here proposed would be quite inadequate for a study of the dynamics of differential growth, it is the opinion of the writer that rectilinear functions will prove sufficient for nearly all taxonomic use, at least on the level of species identification, even after sufficient data for the determination of higher curves become available. And, so long as they will suffice, these first power functions are, of course, infinitely preferable to functions of higher powers, in view of their much greater simplicity in use. For reasons that are too obvious to require elaboration here, it would in fact be utterly

² The rectilinear functions differ from the curve by more than one per cent of L only between 75 and 90 mm. L, and by a maximum of only 2 per cent around 80 mm. It should also be kept in mind that the area of greatest deviation between the curve and the rectilinear functions is also the area in which the widest scattering of individual measurements is normally to be expected, which makes precision of mathematical expression over the range of maximum deviation less important for practical taxonomic use.

³ The indicated range of variations around the norm above 80 mm. L only takes into account the measurements made by the writer himself, since there are some indications in the literature of a tendency to discount the so called "adipose ridge" in recording the depth of the body, which may account for some of the low values of body depth reported for some of the larger specimens.

impracticable to use higher functions in the daily task of identifying material, until the verbal keys for the identification of the species can be replaced with complete charts representing the typical curves for each species of a genus in a single diagram for each taxonomically significant proportion. In this connec-

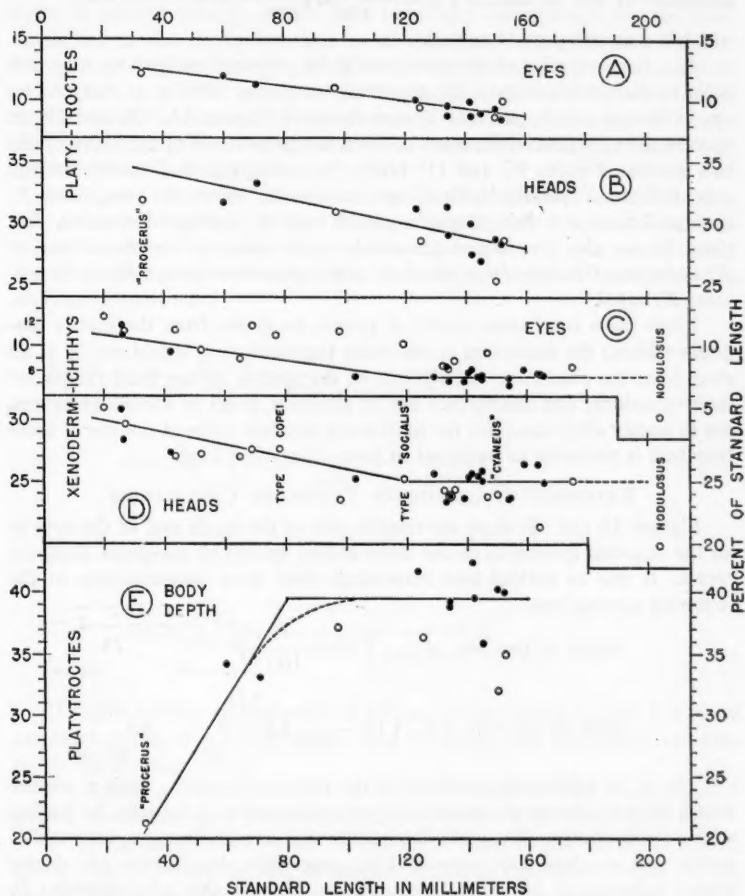


Fig. 1. Proportions against standard lengths.

Platytroctes apus: eyes (A), heads (B), depth of body (E). *Xenodermichthys copei* and *X. nodulosus*: eyes (C), heads (D). Dots represent original measurements, which have been given special consideration in fitting the lines. Open circles represent literature records.

tion it should be also kept in mind that the first-power functions for the relationship between relative dimensions and absolute lengths which have been proposed herein, actually already represent second-power approximations to the relationship between absolute measurements. To get the actual diameter of the eye of *Platytroctes apus*, in mm., it is necessary to multiply (1) by

$\frac{L}{100}$, since (1) alone gives the diameter only in per cent of L . This multiplication gives

$$\text{Diameter of eye in mm.} = \left(13.6 - \frac{3}{100}L\right)\frac{L}{100} = .136L - .0003L^2,$$

which is a second-power function.

As a demonstration of the usefulness of the proposed method, we may now point to the confirmation of the previously suspected identity of *Platytröctes apus* Günther and *P. procerus* Brauer shown in Figures 1A, 1B, and 1E, in spite of the very great differences between the proportions of the types of the two species. Figures 1C and 1D verify the synonymy of *Xenodermichthys copei* Gill and *X. socialis* Vaillant, and removes any reason for recognizing *X. cyaneus* Brauer as a distinct species on the basis of existing information. But these figures also give added taxonomic significance to the proportions of *X. nodulosus* Günther, from which it might otherwise seem difficult to separate *X. copei*.

While these conclusions could, of course, be drawn from the scatter diagrams without the derivation of the linear functions, they would not be at all clear from the customary descriptions of the species, giving fixed ranges for their variations; and descriptions are, of necessity, given in words and figures, not in scatter diagrams. But the potentially greatest value of the use of these functions is probably to be found in cases of another kind.

EXTENSION OF CUSTOMARY TAXONOMIC COMPARISONS

Figures 2A and 2B show the relative size of the heads and of the eyes in all the recorded specimens of the three known species of the genus *Bajacalifornia*. It will be noticed how surprisingly well these measurements fit the following descriptions:

$$\begin{aligned} \text{Heads in per cent of } L : & \left(38 - \frac{7}{100}L\right) \xrightarrow[17-200]{+3} 24 \xrightarrow[200]{-1} \\ \text{Eyes in per cent of } L : & \left(13 - \frac{17}{400}L\right) \xrightarrow[17-200]{+.5} 4.5 \xrightarrow[200]{-.5} \end{aligned}$$

The fit is particularly striking in the case of the eyes. Such a picture would seem to give good reason to suspect that one may actually be dealing with a single species. But other characters, such as pyloric caeca, interorbital width, and absolute size, supported by geographic distribution (*B. drakei* Beebe, Atlantic; *B. burraigei*, Townsend and Nichols, Gulf of California; *B. calcarata* [*Bathytroctes calcaratus*] Weber, East Indies) make it fairly certain that we are dealing with three taxonomically distinct, but closely related forms. What the picture suggests is, therefore, that the morphological differentiation of related species may proceed according to identical or nearly identical formulas. The important consideration here is not the constant typical value of the proportions in the fully differentiated adults, but the function expressing the proportions during the process of differentiation:

$$\left(38 - \frac{7}{100}L\right) \text{ for the heads; } \left(13 - \frac{17}{400}L\right) \text{ for the eyes}$$

particularly the coefficients of slope, or rates of change, in these proportions

$$\left(\frac{7}{100}L \text{ and } \frac{17}{400}L\right).$$

If the indications given by the three species of *Bajacalifornia* should prove to be of general validity, it will have important consequences for the taxonomic use of the expressions here proposed. But, before we look for confirmation among other groups, it might be worth pointing out another feature of Figures 2A, and 2B, namely the demonstration of how the formulas for the later differentiation are abruptly changed, with complete reversal of the directional signs for the slopes, when we trace the development backwards into the larval and early postlarval stages.

In Figures 2B and 2C the changes in the proportions of two related, but unquestionably distinct, species of *Alepocephalus* are compared, and it is found that these changes both in regard to heads and to eyes are naturally fitted by lines of *identical* slope, but with slightly different constants. The expressions used are:⁴

$$\text{Head: } giardi : \left(37.5 - \frac{11}{600}L\right) \xrightarrow[80-600]{\begin{smallmatrix} +2 \\ -2.5 \end{smallmatrix}} 26.5 \xrightarrow{600}^{\pm 1}$$

$$rostratus : \left(36.3 - \frac{11}{600}L\right) \xrightarrow[50-400]{\pm 2} 29 \xrightarrow{400}^{\begin{smallmatrix} +2 \\ -3 \end{smallmatrix}}$$

$$\text{Eye: } giardi : \left(12.5 - \frac{7}{600}L\right) \xrightarrow[80-600]{\begin{smallmatrix} +1 \\ -1.5 \end{smallmatrix}} 5.5 \xrightarrow{600}^{\pm .5}$$

$$rostratus : \left(12.2 - \frac{7}{600}L\right) \xrightarrow[50-400]{\pm 1} 7.5 \xrightarrow{400}^{\pm 1}$$

If this is a fairly general state of affairs among related species, and there are other examples pointing in the same direction, two conclusions of taxonomic significance follow.

1. Similar or identical values for the coefficients of slope become useful criteria and measures of relationship, in conjunction with other characters.

2. If the coefficient of slope is subject to little, or no, variation among nearly related forms, specific differences will find expression chiefly in the constant, K, of the function for the changes in proportion with growth in (1).

The first conclusion does not need further elaboration here, but the second conclusion has very useful practical applications in the taxonomic study of scarce material, such as deep-sea fishes. If an identical, or nearly identical, slope-factor reasonably fits the measurements of two or more species of a genus, with two or more specimens recorded of each, one may, for the purposes of a first consideration of a related new species, assume that the same

⁴With such excellent agreement between all the new and previously published measurements, including those from specimens of nearly the same size, the writer is inclined to view with suspicion the isolated record of a very large head in a small specimen, as shown in Figure 2C. This record has, therefore, been disregarded in the formula for the heads of *giardi*. If the record should be valid it might be taken to suggest the possible presence of a second species.

coefficient of slope will be valid for that species, also. Using this coefficient,

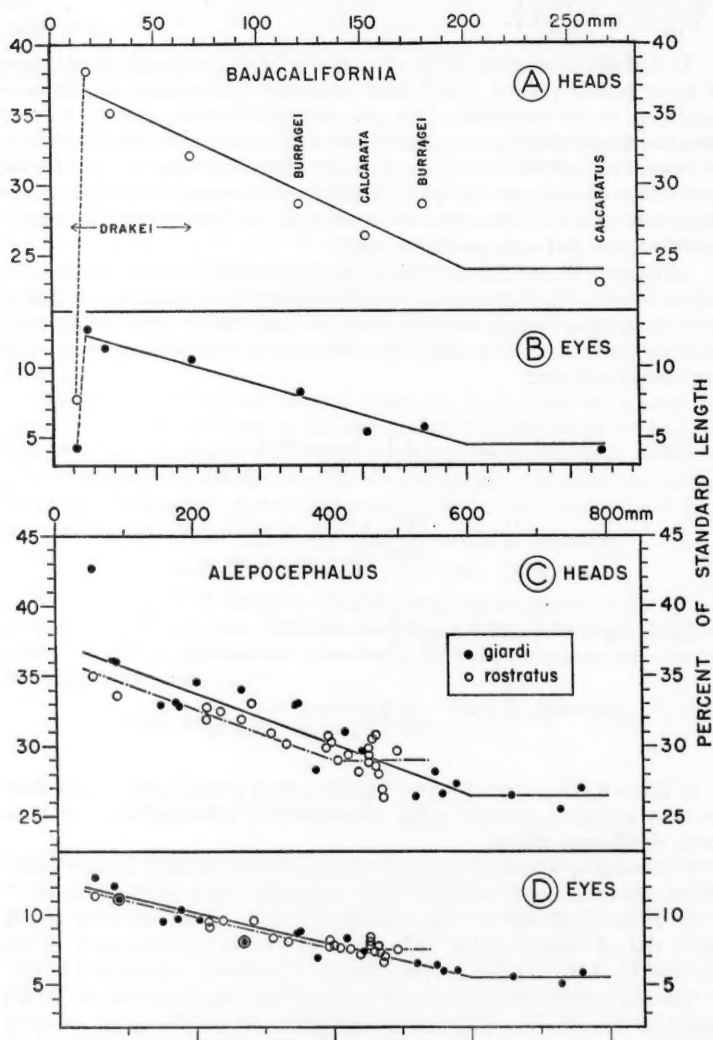


Fig. 2. Proportions against standard lengths. All measurements from the literature.

Genus *Bajacalifornia*: heads (A), eyes (B); species as indicated in the diagram. *Alepocephalus giardi* and *A. rostratus*: heads (C), eyes (D).

one will then be able to make a tentative determination of the value of K for the new species, which will give a figure of far greater usefulness than that of

the direct measurements, in trying to make a significant comparison with related forms.

As an example we find that the recorded relative lengths of the heads plotted against L can be reasonably fitted by the use of a slope factor of $\frac{1}{100}L$ for 20 specimens of *Bathytroctes alvifrons*, 4 specimens of *B. michael-sarsi*, and 3 specimens of *B. squamosus*, with quite different constants for each species. On the other hand we have only single records of the proportions of *B. nasutus*, *B. curvifrons* and *B. melanocephalus*. If these records are given in the customary manner, as in the first column below, we get merely a continual integration from which it is difficult to draw any conclusions. In the second column we have assumed that the slope which fits three species will fit all six, and the comparison immediately takes on a new significance.

HEADS IN PER CENT OF STANDARD LENGTH, IN SPECIES OF *Bathytroctes*

<i>curvifrons</i>	25	or	$\left(26 - \frac{1}{100}L\right)_{107}^{+.07}$
<i>squamosus</i>	25.5-28.5	or	$\left(28.5 - \frac{1}{100}L\right)_{140-270}^{\pm 1.5}$
<i>nasutus</i>	30	or	$\left(31.5 - \frac{1}{100}L\right)_{160}^{+.1}$
<i>michaelsarsi</i>	30.5-33.5	or	$\left(35 - \frac{1}{100}L\right)_{280-380}^{\pm 1}$
<i>alvifrons</i>	33-39.5	or	$\left(37.5 - \frac{1}{100}L\right)_{90-350}^{+.3}_{-2}$
<i>melanocephalus</i>	40	or	$\left(41 - \frac{1}{100}L\right)_{107}^{+.07}$

The same methods of expression and treatment that have here been used for proportions relative to standard length can, of course, also be used for the proportions between other measurements such as, for instance, the diameter of the eye relative to the length of head, and so on. But these illustrations should suffice.

While an attempt has been made to make the best and most reasonable fit obtainable by visual inspection, it goes without saying that, when the data are so few, the best fit in the eyes of any observer is not necessarily the only good fit, and that all the functions used in this article are only in the nature of very rough approximations. But greater precision can only follow from wider application, which is the reason for submitting these suggestions to the criticism of the practicing ichthyologists at this time.

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK, NEW YORK.

Ecology, Breeding Habits and Young Stages of *Crenichthys baileyi*, a Cyprinodont Fish of Nevada

By JOHN A. KOPEC

AMONG the most interesting fishes of the isolated drainages of the arid American west are those that constitute certain highly localized endemic genera (Hubbs and Miller, 1948 *a-b*). Since very little is known about their ecology and life history, a study was made of one of the species, *Crenichthys baileyi* (Gilbert).

This fish was originally described as *Cyprinodon macularius baileyi* by Gilbert (1893: 233), who emphasized the lack of pelvic fins but failed to note that the teeth are bifid, rather than trifid as in *Cyprinodon*. Jordan and Evermann (1896: 675) recognized the species as distinct, but still retained it in *Cyprinodon*, not appreciating its relationship with the genus *Empetrichthys* (Gilbert, 1893: 233-234, pl. 5; Miller, 1948: 99-111, pls. 10-11), which is confined to the springs of Ash Meadows and Pahrump Valley, Nevada. The species *baileyi* was shown by Hubbs (1941: 68) and Hubbs and Miller (1941: 1-2) to be wide-spread in warm springs throughout the remnants of the Pluvial White River system, Nevada (Hubbs and Miller, 1948 *b*: 7-8, pls. 3 and map 2), and to be referable to the genus *Crenichthys*, which Hubbs (1932) had established for a newly discovered species, *C. nevadae*, of Railroad Valley, Nevada. On the basis of identifications by Hubbs, *Crenichthys baileyi* was also reported by Sumner and Sargent (1940) and by Sumner and Lanham (1942), in their studies on the adaptation of fishes to warm-spring waters.

Previous attempts to culture *Crenichthys* in aquaria have proved unsuccessful, although desert forms of *Cyprinodon* have been reared, as by Cowles (1934), Miller and Miller (1942) and Miller (1948: 122-126).

DISTRIBUTION AND ECOLOGY

Crenichthys baileyi occurs not only in a number of isolated warm springs and their creek outflows in the White River and Pahranaagat valleys, but also in the warm-spring headwaters of the Moapa, or Muddy River, which flows into the Virgin River arm of Lake Mead. In the Moapa springs it is associated with *Moapa coriacea*, which has just been described by Hubbs and Miller (1948 *b*: 1-14, Map 2, pl. 1, fig. 1) as a generic relict confined to these restricted waters. Other associates are the introduced *Gambusia affinis affinis* Baird and Girard and, in the spring-fed streams, a local form of *Gila robusta* Baird and Girard.

The ecological characteristics of the Moapa River spring headwaters, as well as the past and present hydrographic and faunal relationships of this river, have been discussed by Hubbs and Miller (1948 *a-b*). Their account of the ecology includes some results from my field studies of December, 1947.

The many warm springs of the Moapa Valley make up the headwaters of the Moapa, or Muddy River. Some of these springs have a rather slow current with large pools measuring up to 7 feet in depth and 25 feet in diameter. Others form streams that run swiftly and cool rapidly. The water maintains

a nearly uniform temperature at the spring sources. In December, 1947, the readings were 90° F. at each spring tested. The pH. ranged from 7.4 to 7.5. The bottoms of the streams are generally muddy with some rocks protruding.

A grass-like plant, *Eleocharis acicularis*, abounds in the faster currents. Some of these plants live entirely out of the water, others are partly submerged and still others are wholly submerged with at least 3 feet of water over them.

Two species of mollusks also inhabit these warm waters, a small elongate spiral form, *Tryonia clathrata* (Stimpson), and a round form, *Ammicola micrococcus* (Pilsbry).

Many schools of *C. baileyi* were observed in one large pool where most of the collecting was done. The schools consisted of not more than 25 individuals; however, in the smaller and swifter streams the schools comprised as many as 250 fish. This greater abundance in the swifter water may be due to a more ample food supply.

In the larger pools the fish were observed spawning and one egg was noted on the aquatic fibrous roots of a smoke tree, *Parosela spinosa*.

Live specimens were transported to Los Angeles in 5 gallon water jugs, with a mortality of only 3 fish out of about 150. Specimens of *Moapa coriacea* were brought at the same time and proved to live well in aquaria.

SPAWNING ACTIVITIES

In an effort to induce spawning, an adult male spring fish measuring 70 mm. and 2 adult females, slightly smaller, were placed in a standard 15-gallon aquarium, with a 75-watt heater regulated by a thermostat set at 90° F. A small aquarium air pump supplied the necessary aeration. The aquarium was heavily planted with *Anacharis*, *Myriophyllum*, *Vallisneria* and other standard aquarium plants. The fish were fed *Tubifex* worms, *Daphnia*, and prepared fish food throughout the experiment.

The male began his courting behavior the same evening, approaching a female distended with eggs at a 45° angle, head down, at a distance of 1 to 3 inches. Usually his courtings took place in front of the female where he would presumably be seen. He displayed intense colors, the mid-dorsal marking becoming very dark gray—almost black—in striking contrast to the almost white sides above the black lateral streaks or fused rows of spots. The fins were all trimmed with black margins. The female's colors were less intense but with the same general markings. Her dorsal line was merely brownish.

The male approached along the side of the female and tried to corner her in some thick vegetation. Soon they went into an S-shaped clasp, both fish vibrating very fast as they lay on their sides. The anal fin of the male was folded under the female's now enlarged ovipositor, supposedly to insure a pathway for the sperm directly on to the egg as it was being deposited. The adhesive egg fell onto the nearest vegetation and adhered tightly. After the sex act the female lay for a moment as if in a coma after which she swam quickly out across the tank. The act of copulation took about one second. Mating and egg-laying were repeatedly observed to follow the same general pattern.

At times the female, ready to deposit an egg when the male was not nearby, went into the floating vegetation, lay on her side and vibrated. This activity appeared to stimulate the male to take part in the spawning process.

Only one egg is layed and fertilized at a time. The act is repeated until from 10 to 17 eggs are deposited at each spawning. The eggs measure 1.9 mm. in diameter. By isolating freshly layed eggs singly in floating vials in the aquarium, the incubation period was found to vary from 5 to 7 days.

The male does not seem to be very pugnacious except when his intentions are interrupted by another fish. He will then turn and chase the intruder away, nudging it ferociously. In general, the fish are peaceful and show no sign of cannibalism. All the young may be raised safely in the same tank with the adults.

YOUNG STAGES

Newly hatched young and later stages (fed on Infusoria and *Daphnia*) were sampled for description. The specimens were mounted on depression slides after being preserved in alcohol. Measurements were made by means of a mechanical stage from the tip of the snout to the vertical passing through each given point, according to the method devised by Hubbs and Cannon (1935: 8-9) and applied by Koster (1948) to a similar study of the young stages of another cyprinodont, *Plancterus kansae* (Garman).

PROLARVA

The yolk sac of the newly hatched larva is very prominent. Ten caudal rays are developed. The pectoral fin could not be found although one is suggested mid-ventro-laterally on the yolk sac. There are 6 myotomes anterior and 20 posterior to the anus. Neither dorsal nor anal fins are evident.

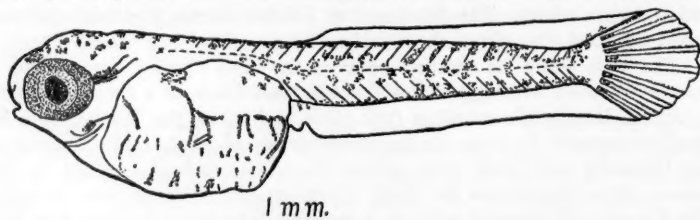


Fig. 1. Newly hatched prolarva of *Crenichthys baileyi*, 4.3 mm. in standard length.

The dorsal and anal finfolds are continuous with the caudal fin. One patch of melanophores is present between the eyes. Immediately over the brain is a second larger patch, the cells of which diminish progressively in number laterally and ventrally. These melanophores over the brain are the largest of the entire larva, measuring up to 0.1 mm. in spread. The lateral surface of the yolk sac has interrupted linear chromatophores with streamers running vertically and connected with one another dorsally by a horizontal line. The pigment of the streamers is interrupted more and more toward the ventral side and becomes less intense toward the posterior end of the yolk sac near the anus. The mid-dorsal and mid-ventral surfaces are rather heavily pig-

mented. The dorsolateral surface of the abdomen contains approximately 2 to 4 melanophores per myotome and the ventrolateral surface has a few scattered melanophores ranging from 0 to 2 per myotome. The pattern of the melanophores seems to follow irregularly that of the myotomes. The vertebral line is seen as a black interrupted line running anteriorly to the top of the eye and posteriorly to almost the end of the caudal peduncle. On the base of the caudal fin there is a single vertical row of melanophores, each on an inter-radial membrane. Small melanophores outline the rays on the caudal fin. Pigment cells extend onto the finfolds in two places, near the anus on the anal finfold and above the caudal peduncle on the dorsal finfold.

POSTLARVA

The mouth and head regions of the 87-hour postlarva have developed remarkably. The operculum is evident. There are now 17 rays in the caudal fin. The pectoral fin is visible, with 8 rays, each outlined with melanophores.

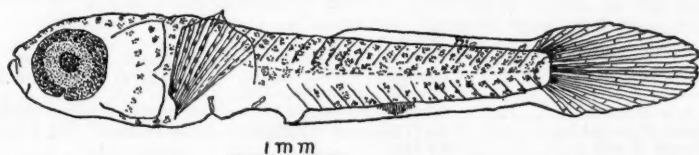


Fig. 2. Postlarva of *Crenichthys baileyi*, 87 hours old, 4.6 mm. in standard length.

There are 9 myotomes before and 17 after the anus. The anal fin bud is streaked with chromatophores which are penetrating the anal finfold. Three melanophores are located near the point where the dorsal fin should develop. Otherwise the pigmentation is essentially the same as that of the prolarva, except that the melanophores have grown more intense.

JUVENILE

At the age of 15 days the caudal fin contains 29 rays, the anal 15 rays, the dorsal 11, the pectoral 13. Remnants of the finfolds are still present anteriorly to the anal fin, anteriorly, both dorsally and ventrally on the caudal fin and posteriorly on the dorsal fin. There are 8 myotomes anterior and 16 posterior to the anus. The iris contains blue chromatophores and the pupil is dark blue. Teeth are present. The lips are covered dorsally with small melanophores. A small patch above and posterior to the snout covers the eye region. The brain is covered densely with melanophores. Pigment cells are evenly distributed on the rest of the dorsal surface, but become less intense and fewer in number toward the ventral surface. The melanophores themselves are smaller than in the prolarva but are more numerous.

YOUNG OF 17.7 mm. (STANDARD LENGTH)

The caudal fin contains 30 rays, the anal 16, the dorsal 12, and the pectoral 17. This seems to be the full quota of rays although they are not fully developed. The caudal fin rays are branched twice, instead of 4 times as they are in the adult. Ten heavily pigmented spots extend dorsolaterally along the body behind the head. A slightly smaller number of equivalent spots are

evident on the ventrolateral surface. In the specimen described, 2 of these spots have fused with a vertical pigmented bridge. In an older specimen all of the spots are bridged vertically. The joining pigment bridges have considerably less pigmentation than the rudimentary spots. The head region has evenly distributed melanophores about the dorsal part of the snout around the eye. The dorsolateral surface of the 17.7 mm. specimen has more pigmentation than the ventrolateral surface. The dorsal melanophores are grouped evenly under the now well-developed scales. The ventral surface has no evident melanophores. Four prominent unpigmented spots appear in a semicircular pattern anteriorly to the eye on each side of the snout.

Measurements of the several young stages described are recorded in Table I.

TABLE I

MEASUREMENTS OF YOUNG STAGES OF *Crenichthys baileyi* IN MILLIMETERS AND, IN PARENTHESES, IN HUNDRETHS OF THE STANDARD LENGTH

	Prolarva (newly hatched)	STAGES		
		Postlarva (87 hours)	Juvenile (15 days)	Young (17.7 mm.)
To base of caudal fin.....	4.3 (100)	4.6 (100)	7.3 (100)	17.7 (100)
To end of caudal fin.....	5.3 (123)	5.9 (128)	7.8 (107)	21.2 (119)
To front of yolk sac.....	0.7 (16)	.....	.....	.....
To rear of yolk sac.....	2.0 (47)	.....	.....	.....
To origin of dorsal finfold....	2.3 (53)	2.8 (61)	.....	.....
To origin of anal finfold.....	.....	2.4 (50)	.....	.....
To front of dorsal fin base.....	.....	.....	4.8 (66)	12.0 (67)
To rear of dorsal fin base.....	.....	.....	5.7 (78)	14.2 (80)
To front of anal fin base.....	.....	.....	5.0 (68)	11.8 (66)
To rear of anal fin base.....	.....	.....	6.0 (82)	14.6 (82)
To origin of pectoral fin.....	.....	1.4 (30)	2.7 (37)	6.4 (35)
To anus.....	2.1 (48)	2.4 (50)	4.9 (67)	11.8 (66)
Head length.....	0.8 (19)	1.3 (28)	2.3 (31)	5.2 (29)
Snout length.....	0.1 (2)	0.2 (4)	0.4 (5)	0.9 (3)
Eye length.....	0.5 (12)	0.6 (13)	0.9 (12)	1.7 (9)
Body depth thru origin of dorsal finfold.....	0.4 (9)	0.6 (13)	.....	.....
Greatest body depth.....	1.2 (27)*	0.9 (20)	1.6 (22)	5.0 (28)
Caudal peduncle depth.....	0.2 (5)	0.3 (6)	0.9 (12)	2.5 (19)
Dorsal fin height.....	0.2 (5)**	0.1 (2)**	0.4 (5)	1.8 (10)
Longest dorsal ray.....	.....	.....	1.0 (13)	2.3 (13)
Anal fin height.....	0.2 (5)**	0.1 (2)**	0.3 (4)	1.9 (10)
Longest anal ray.....	.....	.....	.....	2.1 (12)
Pectoral fin length.....	0.7 (15)	0.8 (11)	2.6 (14)

* Depth through center of yolk sac.

** Height of finfold.

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The author wishes to express his thanks to Dr. Carl L. Hubbs, of Scripps Institution of Oceanography, and to Dr. A. Weir Bell and Dr. Sherwin F. Wood, both of Los Angeles City College, for their helpful suggestions and criticisms in preparing this manuscript.

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Vertebral Counts in Four Species of Suckers (Catostomidae)¹

By RICHARD C. SNYDER

RECENTLY, Raney and Lachner (1947) described *Hypentelium roanokense*, a dwarf species of hog sucker adapted to life in small mountain streams of the upper headwaters of the Roanoke River system. It shares the Roanoke system with *Hypentelium nigricans* (LeSueur), the widely ranging species sometimes found in the same habitat. It differs from *nigricans* in having a heavier body with a foreshortened trunk, scales and pectoral rays markedly reduced in number, longer anal and dorsal fins, larger and less inferior mouth, and in several pigmentary features. In addition, the posterior fontanelle is reduced to a narrow slit and the posterior lobe of the air bladder is short and thin.

Vertebral counts were made of the above two species of *Hypentelium* to determine the degree of differentiation that exists, if any, and to discover whether or not the reduction in number of scales of *Hypentelium roanokense* is paralleled by a reduction in vertebral number. Similar counts were made on *Catostomus c. catostomus* (Forster) and *Catostomus c. commersonnii* (Lacépède), since these species also differ in scale counts, the latter having the smaller number in the lateral line.

The vertebral counts were made after the manner described by Hubbs and Lagler (1947) by examination of the negatives of roentgenograms, except for those of *Catostomus c. commersonnii* in which the vertebrae were counted *in situ* after dissecting off one complete side of the fish. The roentgenograms were made of the lateral aspects of the fish with a Westinghouse 150 KV pedestal-mounted X-ray unit on 14 × 17 Type M industrial film. All fish were X-rayed at 50 KV, 15 milliamps at 45 seconds for the larger fish and 40 seconds for very small ones (60 mm. or less). The best results were obtained by omitting the use of a lead screen between the film and the fish. Gosline (1948) and Bailey and Gosline (1948) have recently indicated the value of using X-rays for ichthyological work.

At first, some difficulty was experienced in counting the vertebrae due to the presence of the Weberian ossicles. Krumholz (1943) stated that in ostariophysine fishes these structures are derived from the first four vertebrae. Watson (1939) noted that in the goldfish, *Carassius auratus* (Linnaeus), the fourth vertebra bears a rib. Studies of suckers, cleared and stained with alizarine, confirm the findings of both. The vertebrae of these suckers were counted by beginning with the fourth (the first rib-bearing) vertebra and then adding three to the total.

The distribution of the vertebral counts is shown in Table I. The range in numbers of vertebrae for all four species is from 38 to 48, a considerably greater range than the numbers (45 to 47) given by Jordan and Gilbert (1882) and Jordan and Evermann (1896) for all *Catostomus* (including *Hypentelium nigricans*). Günther (1868) stated that there are 47 vertebrae in *Catostomus commersonnii* (*teres*).

¹Dr. Edward C. Raney of the Zoology Department, Cornell University, provided the specimens for this study and critically examined the data and manuscript. The X-ray equipment was made available through the kindness of Prof. W. J. Furcell, of the Department of Engineering Materials, Cornell University.

TABLE I
VERTEBRAL FREQUENCIES OF FOUR SPECIES OF CATOSTOMIDAE

The 103 *Hypentelium roanokense* are from the upper Roanoke River system; the bulk of the 94 *Hypentelium nigricans* are from the Roanoke, Susquehanna, Lake Ontario, Tennessee and Ohio River systems; the 70 *Catostomus c. commersonnii* are from the upper Genesee River system in New York; and the 41 *Catostomus c. catostomus* are from several drainages in northern New York.

Number of vertebrae	<i>Hypentelium</i>		<i>Catostomus</i>	
	<i>roanokense</i>	<i>nigricans</i>	<i>c. commersonnii</i>	<i>c. catostomus</i>
38	1	..	..	..
39	17	..	..	..
40	55	..	..	..
41	29	3	..	..
42	1	16	..	..
43	..	38	..	..
44	..	23	3	..
45	..	13	18	2
46	..	1	43	21
47	..	..	6	17
48	..	..	..	1
Total	103	94	70	41
Range	38-42	41-46	44-47	45-48
Mean	40.1	43.3	45.9	47.4
σ	.716	1.19	.692	1.39
σ_m	.049	.086	.058	.153

TABLE II
PRECAUDAL (PC) AND CAUDAL (C) VERTEBRAL FREQUENCIES OF FOUR SPECIES OF CATOSTOMIDAE

The locality data are the same as given in Table I.

Number of vertebrae	<i>Hypentelium</i>				<i>Catostomus</i>			
	<i>roanokense</i>		<i>nigricans</i>		<i>c. commersonnii</i>		<i>c. catostomus</i>	
	PC	C	PC	C	PC	C	PC	C
15	..	1	..	..	..	..	..	..
16	..	4	..	..	..	..	..	..
17	..	37	..	8	..	..	..	1
18	..	50	..	27	..	3	..	8
19	..	10	..	38	..	28	..	17
20	..	1	..	20	..	30	..	13
21	2	..	..	1	..	9	..	2
22	58	..	..	..	..	..	..	..
23	37	..	6	..	..	..	..	..
24	5	..	39	..	..	..	..	..
25	1	..	41	..	13	..	..	..
26	..	..	8	..	39	..	5	..
27	..	..	..	..	16	..	22	..
28	..	..	..	..	2	..	11	..
29	..	..	..	..	..	..	3	..
Total	103	103	94	94	70	70	41	41
Range	21-25	15-20	23-26	17-21	25-28	18-21	26-29	17-21
Mean	22.4	17.6	24.5	18.8	26.1	19.5	27.3	19.2
σ	.628	.790	.744	.918	.725	.776	.783	.893

A significant difference exists in the numbers of vertebrae between the two species of *Hypentelium* and between the two species of *Catostomus*. The counts in *Hypentelium* give further evidence of the differentiation of the two forms on the specific level. When only Roanoke River specimens of *H. roanokense* and *H. nigricans* are compared, there is practically no overlap, since only one individual of each species has a vertebral count of 42. Using the measure of differentiation and intergradation proposed by Ginsberg (1938), a line drawn between vertebral numbers 41 and 42 (Table I) will separate 98 per cent of the individuals (2 per cent intergradation), thus indicating a very high degree of differentiation, clearly on the specific level. The degree of intergradation for the two species of *Catostomus* is 14 per cent. These two species are separable on the lateral line scale counts and other characters. The above comparisons show that, for the species studied, an increase in number of scales is accompanied by an increase in number of vertebrae. Further studies of the correlation of vertebral counts with scale counts in other subspecies of the two species of *Catostomus* would be of interest.

The counts listed in Table II show that the caudal vertebrae vary to a greater extent than do the precaudals in all four species. There are significant differences between both precaudals and the caudals of the two species of *Hypentelium* and between the precaudals only of the two species of *Catostomus*. Hubbs (1924) also found that the caudal vertebrae of *Notropis blennioides* (Girard) are more subject to numerical modification than are the precaudals.

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Notes on a Sturgeon from the Min River, China

By HAN-PO TING

THE Min River is located in Fukien Province, China. It originates at the northwestern border of the province, flows through the middle part of the province towards the east, and empties into the East China Sea. The occurrence of sturgeon in the Min River is rare, and only a few records have been reported. Sowerby (1925) mentioned a specimen caught in 1911 in the river at Foochow but the fish was purchased by a wealthy merchant who set it free again in the river. Because of the rare occurrence of such fish in that region, the superstitious country people believe that it may be a god and that the release of the captured one will bring blessings thereafter. Chen (1938, 1940) reported one specimen collected in 1935 and two specimens collected in 1939. He identified these three as *Acipenser sinensis*.

The specimen to be described in this paper was caught by fishermen on March 10, 1946, at Yangyü, near the mouth of the Min River. The specimen was still alive when it was sold to a fish merchant in Foochow. The man who bought the fish put it in a tank for public exhibition and charged admission. After two days the fish died. It was then bought by the writer and a careful study was made in the fresh condition before it was skinned for making into a permanent mount. The specimen is now in the Museum of Fukien Christian University, Foochow.

The following description applies to the fresh specimen: Body cylindrical, slightly compressed; head dorso-ventrally depressed with a tapering snout which bends slightly upwards at the tip; color on back brownish, on sides golden yellow, on ventrum whitish; tiny sandy granules over the skin of the dorsal and lateral parts of the body; body weight 3.75 kg.; total length 85.0 cm.; body length (standard length) 72.5 cm.; caudal fin length 12.5 cm.; caudal peduncle 8.0 cm.; body depth (highest point) 11.9 cm.; body width 10.1 cm.; head length 18.5 cm.; head depth 8.8 cm.; head width 9.2 cm.; snout length 7.5 cm.; mouth to tip of snout 10 cm.; width of mouth 4.4 cm.; length of barbels 2.0 cm.; interorbital distance 6.0 cm.; internasal distance between anterior nares 3.8 cm., between posterior nares 5.1 cm.; anterior nares to tip of snout 5.62 cm.; posterior nares to tip of snout 6.28 cm.; eye, oval-shaped, 1.28 x 1.0 cm., situated midway between gill slit and tip of snout; pupil glassy; iris golden.

Fin rays: dorsal 45, anal 31, pectoral 40, ventral 34.

Scutes:

Dorsal series: pre-dorsal 14, last one slightly keeled at the posterior half, next to the last consists of two closely joined right and left halves not keeled; post-dorsal three, not keeled; two small scutes on right side and one small scute on left side behind the post-dorsal scutes; each of the first and third post-dorsal scutes consists of right and left halves, the second scute fan-shaped with handle inserted in between the two halves of the first scute.

Lateral series: right 38, left 38; all keeled; last pair very small.

Ventro-lateral series: 14 pairs in front of ventral fins, all keeled; three in front of anal fin, not keeled: first one, smaller, paired and separated; second one consists of right and left halves joined closely together; third one unpaired; three behind anal fin, not keeled: first one fan-shaped with handle pointed posteriorly; second one paired, small and separated; third one narrow.

According to Nichols (1943) the occurrence of *Acipenser sinensis* Gray and *A. dabryanus* Duméril in China has been well known, while the presence of *Huso dauricus* (Georgi) is still questionable. Since there is considerable variation in certain taxonomic characters, such as the number of scutes and fin rays in the former two species, identification is somewhat difficult. Kimura (1935) adopted Mori's (1933) scheme of classification with some modifications, and more recently Nichols (1943) also made a simple key to fit such purpose. For a clearer comparison of the taxonomic characters of those sturgeon found in the Min River with characters given by Kimura and by Nichols for *A. sinensis* and *A. dabryanus*, see Table I.

In Table I it is shown that the range in number of dorsal fin rays of the Min River specimens is intermediate in the ranges of *A. sinensis* and *A. dabryanus* in Kimura's scheme, while the variation in the number of anal fin rays more nearly approaches the range for *A. sinensis*. As to the number of dorsal and lateral scutes, the Min River specimens agree more closely with *A. sinensis*, as described by Nichols. The greater ratio of head length to snout length in the Min River specimens, as compared with those values given by Nichols for *A. sinensis* and *A. dabryanus*, may be due to the fact that Nichols' specimens are younger.

According to the past records, *A. dabryanus* is found mainly in the Yellow River and in the Yangtse River and its lakes, while *A. sinensis* is more widely distributed. For the latter, records have been made from various localities from the Liao-ho basin in northeastern China down to Canton. In Fukien Province, besides these specimens found in the Min River, Wu (1929) has reported a specimen from Amoy (a seaport about 130 miles south of Foo-chow) as *A. sinensis*. From the above comparisons and the geographical distribution, it seems quite safe to say that the sturgeons from the Min River belong to the species *A. sinensis* Gray.

The writer wishes to thank Professor J. W. Price, of The Ohio State University, for reading the manuscript and giving valuable criticisms.

See Table I.

*Measured from dry mounted specimen.

**The measurements seem doubtful, since the weight given by the author is only 2.5 kg. The present writer's specimen weighed 3.75 kg. and measured only 85.0 cm.

***In examples of 12-15 inches.

TABLE I
TAXONOMIC CHARACTERS OF *Acipenser sinensis* AND *A. dabryanus*

Characters	Cheng's specimens			Writer's specimen	Range for Min River specimens	Kimura's scheme		Nichols' scheme	
	'38	'40	'40			<i>sinensis</i>	<i>dabryanus</i>	<i>sinensis</i>	<i>dabryanus</i>
Total length (cm.)	83*	166**	94.5*	85.0	...	...	...	...	...
Body length (cm.)	65	138**	76	72.5	...	...	...	...	...
Body length/head length	3.5	4	4	3.9	3.9	...	...	...	...
Head length/snout length	2.3	3	2.5	2.5	2.6	...	...	<2***	2***
Fin rays	53	50	49 (50)?	45	45-53	50-60	40-49	...	...
	35	33	32	31	31-35	33-38	27-30	...	...
Anal	44	38	..	40	37-44	...	...	...	...
	..	37	..	..	...	...	...	...	...
Ventral, right left	32	30	31	34	30-34	...	...	...	...
	..	32	32	..	...	...	...	...	...
Scutes	15	17	16	14	17-19	16	12-14	17	9-12
	3	2	3	3	...	...	...	...	...
Lateral, right left	38	40	40	38	36-42	40-46	32-37	36-41	33-35
	36	39	42	38	...	...	...	...	...
Ventral, right left	13	16	12	14	11-16	14	10-14	...	...
	11	14	13	14	...	...	...	...	...
Between ventral and anal	2	3	2	3	2-3
Behind anal	3	1	2	3	1-3

* For footnotes, see page 66.

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Ichthyological Notes

TWO NEW GENERA OF SCORPAENOID FISHES.—Max Weber described three new species of *Paracentropogon* in the Siboga report (1913, Leyden: 499-501), but of none of them was he quite sure that they really belonged to this genus. An examination of the types and paratypes convinces me that they cannot be kept in *Paracentropogon*. *P. cynocephalus* and *P. pleurostigma* differ from *Paracentropogon* in lacking palatine teeth, in having a greater number of pectoral rays (13-15, against 9-10) which moreover are not forked, and in having six instead of five anal rays. The combination of these differences is sufficient to place these two species in a genus of their own, which I call *Sibogapistus*, selecting *P. cynocephalus* as the type of the genus.

The third of Weber's species, *P. aeglefinus*, is more like *Prosopodasys* than *Paracentropogon*. It agrees with the first named genus and differs from *Paracentropogon* by the origin of the dorsal which is not in, but behind, the vertical through the eye, by having five instead of four ventral rays, and by having the lower jaw projecting and provided with a symphyseal knob. It differs from *Prosopodasys* in that the three anterior dorsal spines are not separated from the rest of the fin, and it differs from both *Paracentropogon* and *Prosopodasys* by having seven instead of four or five anal rays. Hence it cannot be fitted into one of these genera without altering and obscuring their diagnoses, and there remains but one thing to do: to create a new genus for it which I propose to call *Gadapistus*.—L. F. DE BEAUFORT, Zoological Museum, Amsterdam, Netherlands.

HYBRID OF CHINOOK AND SILVER SALMON FROM PUGET SOUND.—

Hybridization of salmon is not rare, but records of crosses between the silver (*Oncorhynchus kisutch*) and the chinook (*O. tshawytscha*) are unknown to the writers. Foerster (1935, Trans. Roy. Soc. Canada, 3rd Ser., Sec. V, 29: 21-33) reported a hatch of only a few abnormal fish resulting from artificial crossbreeding of these two species.

The specimen described here was obtained by Mr. Stephan Fallert and Mr. Frank Hilsinger of the Samish Salmon Hatchery, Washington, between December 6 and 13, 1947, in a trap in the Samish River. Mr. Fallert said:

Both silvers and chums were running at the time but it was frosty weather and there were only a few of each species. The salmon in question was light red in color, slightly lighter than the silver males that were in the trap with it. Its body characteristics, except color, were those of a chinook (its large size, the main reason) but the color and shape of the head were characteristic of the silver.

Measurements and other observations on the frozen specimen follow:

Fork length	93 cm.
Weight (on December 16, 1947)	11.04 kilograms (24.3 pounds)
Fin rays, dorsal	10
Fin rays, anal	15
Fin rays, pectoral	15
Fin rays, pelvic	10
Scales in lateral line	132
Scale rows above lateral line counting diagonally either forward or backward from insertion of dorsal fin	28-29
Scale rows below lateral line counting diagonally forward from insertion of pelvic fin	32
Branchiostegal rays	17 left, 15 right
Gill rakers	23 left, 24 right
Vertebrae	64
Pyloric caeca	96
Weight of liver	230 grams
Weight of spleen	54.2 grams
Weight of ovaries	211 grams
Number of eggs	325

The ovaries were removed, treated with warm water and pressure to isolate 298 eggs. The other 27 eggs remained attached to the ovarian tissue. There was evidence that some eggs had been shed but it is believed that fewer had been shed than remained.

Examination of 11 scales from the back above the lateral line resulted in a questionable interpretation of age. However, the four persons who attempted to age the scale did concur in the opinion that the fish was a 4-year-old showing one annulus in fresh water and two in salt water, with considerable erosion at the periphery of the scale.

Deficiency in sexual development was manifest in the unspawned external appearance of the fish and in the small size of the ovaries. The body wall, instead of being thin as in sexually ripe females, was nearly 2 cm. thick.

Mr. Elmer Quistorff, superintendent of the Washington State Department of Fisheries Issaquah Salmon Hatchery, wrote in personal correspondence that an occasional silver-chinook hybrid has been observed in Issaquah Creek, where the spawning of the two species overlaps in both time and locality, and that cross-mating has been frequently observed on the spawning grounds. One specimen, which Mr. Quistorff remembered clearly, was taken in 1944. It was a large, red, ripe male taken from the trap where both chinook and silver salmon were being caught for spawning. This specimen, although of the red color characteristic of spawning silver salmon, exceeded the normal upper size range of silvers by 5 or 6 inches. The small caudal peduncle, a chinook trait, was recognized when the tail was grasped. The anal fin and tail were chinook-like, while the general appearance, especially of the head, and the small number of pyloric caeca resembled the silver salmon.—K. BONHAM and A. H. SEYMOUR, *Applied Fisheries Laboratory, University of Washington, Seattle 5, Washington.*

NOTES ON THE MAINE SHARK FISHERY.—Along the Maine coast, *Lamna nasus*, commonly known as the mackerel shark by New England fishermen, appears to be second in abundance only to the spiny dogfish (*Squalus acanthias*). As the mackerel shark often swims in the surface waters, it is seen to a greater extent by boatmen than other common sharks which dwell near the bottom. The commercial catches of mackerel

sharks and dogfish seem to indicate that these two species predominate in the cold water area of the Gulf of Maine.

In the past, the spiny dogfish has been used in the manufacture of fish meal and has been sold as "grayfish," either fresh or canned, but since the First World War, *Squalus acanthias* has had such little value that the great bulk of captured dogfish has been discarded at sea. The appearance of schools of this species on a fishing ground results in cessation of hook and line fishing, for the dogfish monopolize almost all the hooks and thereby make it difficult to capture any of the valuable groundfish such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), hake (*Urophycis* species), or pollack (*Pollachius virens*). The dogfish is regarded universally as a nuisance by the fishermen of New England. Yet, because of its great numbers, this fish represents one of our latent fishery resources. No organized attempt was made to utilize the spiny dogfish during the Second World War.

Lamna nasus is the commercially valuable shark in Maine waters. It is sold fresh and, because its meat resembles that of the swordfish (*Xiphias gladius*) in both appearance and taste, I suspect that at least some of the shark meat is sold as swordfish. According to the fishery statistics collected in sixteen of the twenty years between 1928 and 1947, by the U. S. Bureau of Fisheries, the U. S. Fish and Wildlife Service, and the Maine Department of Sea and Shore Fisheries, a yearly average of about 42,000 pounds of sharks has been caught in Maine. This catch has been produced by gear fishing primarily for other species. There has not been a strong demand for shark meat and, as the fish liver oil processors have not considered the mackerel shark liver to be particularly valuable as a source of vitamin A, there has been no incentive for any organized fishery for this species. The statistics indicate that bottom gill nets caught an average of 83 per cent of the total; long lines, 7 per cent; floating traps, 3 per cent; otter trawls and seines, each 2 per cent; and hand lines, harpoons and weirs, a total of 3 per cent.

The bottom gill net fishery of Maine, which is now carried on by boats operating from the port of Portland, catches groundfish on the nearby coastal banks. The gill nets are quite effective in capturing sharks, for these fish are easily enmeshed in the twine. As the nets are set in depths as great as 50 fathoms, this gear probably catches the sharks below their zone of greatest abundance. If there were a good market for this species, undoubtedly gill nets could profitably be used to capture sharks in intermediate depths or near the surface. An increased production would also result with the substitution of wire leaders for the cordage now used on hand lines and long lines.

Almost all the sharks taken in bottom gill nets are marketed, but it is difficult to state what percentage of the sharks caught by other types of gear is thrown overboard. Undoubtedly the landed catch represents only a small part of the actual poundage taken at sea. Here, again, is a neglected fishery resource, the harvest of which awaits only an increased demand from the consumer.

The seasonal peak of shark abundance, as revealed by the statistics of the monthly landings of fish in Maine, occurs in the period August to November, during which 76 per cent of the sharks were landed in 1940-1947. Herring, mackerel and shad purse seine fishermen often encounter numbers of mackerel sharks while operating their gear along the Maine coast during the summer and fall and consider them as a nuisance for they often tear the nets and allow the entrapped fish to escape. From February to May, these sharks are seldom taken; only about 3 per cent of the total were caught in those four months.

During 1947 and 1948, I had the opportunity to examine 18 mackerel sharks landed at Portland and Eastport, Maine. Before these fish are sold, the fishermen remove the head, fins (sometimes leaving the ventrals), viscera and the tail. Through the courtesy of Captains Willard Parker, of Grand Manan Island, New Brunswick, Canada, and Carl Baade, of Portland, Maine, 6 whole sharks were brought in so that I could identify them and ascertain what conversion factors should be used to convert the dressed or drawn fish to their original lengths and weights. Although 6 sharks comprise a rather small sample, I believe that the conversion factors of 1.6 for changing dressed weights to whole or round weights and 1.7 for converting dressed lengths to whole lengths will serve until more detailed studies of sharks are necessary.

The average dressed length of the 18 sharks was 89.9 cm., with a range of 69 to 145

cms. The average dressed weight of 10 sharks was 23.9 kgs. The largest weighed 44.2 kgs. and the smallest, 10.2 kgs. It was not possible to weigh every measured shark because of the occasional lack of adequate scales. Much larger specimens than those that I examined have been reported by fishermen, but, as a rule, mackerel sharks over 200 pounds round weight are not commonly taken.

The landing of the whole sharks enabled me to examine the stomach contents. Of the 5 sharks from Portland, 2 had empty stomachs. Of the 2 caught on November 10, 1947, one had eaten three squid (*Loligo pealei*), and the other, one alewife (*Pomolobus pseudoharengus*), 3 herring (*Clupea harengus*), and 2 squid. Another shark, caught November 24, 1947, had 3 mackerel (*Scomber scombrus*) in its stomach. A shark caught January 13, 1948, at Grand Manan Island, had eaten 2 rosefish (*Sebastes marinus*). The latter fish are found in shallow water around Grand Manan Island, but in most parts of the Gulf of Maine they are found in water depths of 90 or more fathoms.

The mackerel sharks that I examined had been dead between 6 and 24 hours and probably much of the color had faded from them. The dorsal and caudal fins were uniformly bluish black. The dorsal surface of the pectoral fin was bluish black, except for a small white patch between the posterior insertion of the pectoral and the posterior part of this fin. The ventral surface of the pectoral fin had its anterior and posterior margins rimmed with a narrow black strip. About one-third of the distal part of the ventral surface of the pectoral was black; the remaining two-thirds was mottled white and black, with white predominating as the insertion was approached.—LESLIE W. SCATTERGOOD, U. S. Fish and Wildlife Service, Boothbay Harbor, Maine.

Herpetological Notes

SIZE MAXIMA IN TERRESTRIAL SALAMANDERS.—Of the four families of terrestrial salamanders (Hynobiidae, Ambystomidae, Salamandridae, Plethodontidae) there is no question that the Ambystomidae contain the species that reach the greatest adult size. *Ambystoma tigrinum* holds the record, with adults of *A. t. tigrinum* known to reach 330 mm. in total length, larvae of *A. t. mavortium* 328 mm., and larvae of *A. t. diaboli* 312 mm. Specimens of another neotenic race of this species, unnamed, from the late Pleistocene of Kansas, undoubtedly reached a total length as great as 400 mm., but no living races or species are known to approach this measurement. Almost as large as the tiger salamander is a second member of the same family, *Dicamptodon ensatus*, adults of which attain a total length of 300 mm. The only other ambystomids of comparable size are the permanently larval Mexican genera, *Siredon* and *Bathysiredon*, each of which attains a total length in excess of 250 mm. The body form is similar in all four genera.

It has been thought that none of the other three families contain species even approaching the size of the larger ambystomids. So far as I am aware this is true of the hynobiids and salamandrids, but at least one plethodontid closely approaches the maximum for any terrestrial salamander. This is *Pseudoeurycea* (formerly *Oedipus*) *bellii*, one specimen of which (Univ. Illinois) measures 291 mm. in total length, and 146 mm. snout to vent.—HOBART M. SMITH, Department of Zoology, University of Illinois, Urbana, Illinois.

DEVELOPMENT OF THE SOLITARY SPADEFOOT TOAD IN TEXAS.—Solitary spadefoot toads, *Scaphiopus holbrookii hurterii* Strecker, in Gonzales County, Texas, moved to breeding places during a heavy rain that came the afternoon and night of April 12, 1947. One such breeding place, a small, intermittent creek about 5.5 miles south of Luling, Texas, was located by Alvin Flury. Forty-one individuals were collected during heavy rain squalls early in the night, as they were crossing the highway and moving toward the creek. Many eggs were laid by the females in the sacks in which the spadefoots were transported to the laboratory.

Large quantities of eggs were found in creek-bed pools when I revisited the locality two days later on the afternoon of April 14. A quantity of eggs was collected and taken to the laboratory, where the eggs were kept in pans of water containing submerged aquatic plants. Most of the eggs hatched the next day, April 15, or about two and one-half to three days after they were presumably laid. The larval spadefoots were fed boiled lettuce for the duration of my observations of the laboratory stock. These larvae augmented their diet by occasional cannibalism, eating weak larvae and their relatively helpless, recently transformed brethren if they were not quickly removed from the pans.

Free hind legs were first observable in the laboratory animals on May 2, and the first individual completed metamorphosis on May 6. Several individuals transformed each day thereafter until observations were discontinued on June 3. A sample of the still unmetamorphosed laboratory population, preserved on June 3, showed that of 590 individuals 438 (74.2%) were without free legs, 136 (23.0%) had free hind legs, and 16 (2.8%) had hind and fore legs free and the tail not yet resorbed.

Most of the wild population had metamorphosed when the breeding locality was revisited on May 4. The breeding pools were reduced in depth and area, but one large pool remained and had a depth of 2 feet in one place. Only 6 larvae, all with free hind legs, were caught in repeated sweeps with a dip net in this pool. These few individuals were caught in the deepest part of the pool. Thousands of recently metamorphosed individuals were seen on moist soil which extended out for about 10 feet around the periphery of the breeding pool. None was found in careful searching of dry soil more distant from the water. A sample comprising 163 individuals was collected around the pool. These averaged $10.01 \pm .04$ mm. in body (snout to vent) length.

Development was obviously much more rapid in the wild population than in the laboratory stock. Most of the wild individuals had apparently metamorphosed within three weeks of the time the eggs were laid. Many of the laboratory animals were still unmetamorphosed seven and one-half weeks after the eggs were probably laid. The laboratory animals were kept at room temperature and therefore lived in cooler water than the larvae in the breeding pool, which was subject to warming by the sun. The diet of the laboratory animals differed from that of the wild population, and the laboratory animals were probably more crowded than those in the wild.

Most of the young spadefoots had disappeared when the breeding site was revisited on May 14. A few remained on the moist soil around the now shrunken pool, and 14 specimens were collected. These had an average body length of $10.19 \pm .15$ mm. Since these were significantly no larger than the animals collected there May 4 they may represent a late-transforming section of the original population. An interesting record of dispersal was obtained on the May 14 visit to the breeding locality. Several pocket-gopher burrows (of *Geomys breviceps*) were opened for the setting of gopher traps about one-fourth mile from the breeding pool. Two young spadefoots were found in one of these open gopher-burrow entrances when the traps were run late in the afternoon. It is not known whether the juvenile spadefoots were living in the gopher burrow or whether they had fallen into the depression made by excavating the burrow entrance. One of these was preserved, and it measured 9.7 mm. in body length, which is even less than the average of those that had not dispersed from the breeding site. The creek-bed pool one-fourth mile distant was the nearest spadefoot breeding site, and it seems likely that these juveniles had dispersed from the vicinity of that pool.—W. FRANK BLAIR, *Department of Zoology, University of Texas, Austin 12, Texas.*

RANGE OF CANE-BRAKE RATTLESNAKE IN FLORIDA.—That the range of the cane-brake rattlesnake, *Crotalus horridus atricaudatus* Latrielle, extends into the base of the Florida Peninsula is demonstrated by collections of this species made for the Reptile Institute of Silver Springs, Florida, which amount to 23 specimens received since



Fig. 1. Range of *Crotalus horridus atricaudatus* in Florida. The map shows also the divisions of the state found useful in distributional studies.

1934. These amplify the records of Gloyd (Sp. Publ. Chicago Acad. Sci., 4: 189) from northern Florida. Specimens have been collected at or near the following locations:

- Gadsden County; near Wetumpka.
- Liberty County; at Orange and near Wilma.
- Suwanee County; near Branford, near Padlock, and north of Luraville.
- Columbia County; at Columbia, near Mason, and near Ft. White.
- Baker County; in Osceola National Forest, near Manning, and south of Sanderson.
- Union County; at Dukes and Lake Butler.
- Bradford County; south of Starke, near Hampton, near Lawtey, near New River, and north of Waldo.

Alachua County; near Worthington Springs.

Duval County; near San Pablo, near Dinsmore, and near Baldwin.

The southernmost record of this rattler in Florida was found August 18, 1948, in Bradford County, 5½ miles north of Waldo, toward Starke, along the Seaboard Railroad by M. E. De Shea, Waldo Railway Agent.—E. ROSS ALLEN, *Reptile Institute, Silver Springs, Florida*.

EXTENSION OF RANGE OF *CROTALUS LEPIDUS KLAUBERI*.—While collecting mammals for the reference collection of the University of Miami, the authors were fortunate in securing a specimen of *Crotalus lepidus klauberi*. This specimen was collected on the Manzanital Ranch, owned by Mr. Wallace H. Pratt, located 6 miles north of Pine Springs on U.S. 62 and 180, and 6 miles to the west of the highway, Culberson County, Texas. Gloyd, in his monograph on the rattlesnakes, published in 1940, indicates that the only Texas locality record is from El Paso County. The present specimen thus extends the range of this subspecies about 110 miles to the east in Texas. The snake was collected by Mr. Louis Kincaid, June 25, 1948, at an elevation of about 5000 feet in the Guadalupe Mountains, as it lay on a rock slab, basking in the early afternoon sun. It measures 61.6 cm., not including the rattle, which is composed of 9 segments. Scale count, 23–23–17. Coloration—body ground color light blue-gray peppered with dark brown granules; 19 dark body bands; tail tan with 3 bands varying from brown to tan posteriorly; ventrals light flesh colored with brown lateral blotches.—ALBERT SCHWARTZ and WILLIAM A. BABIS, *University of Miami, Coral Gables, Florida*.

A PREOCCUPIED NAME IN *HYLA*.—In a recently published paper (Univ. Kansas Publ. Mus. Nat. Hist., 1[15], Aug. 16, 1948: 257–262) I described a new Mexican frog under the name *Hyla proboscidea*. This I find is preoccupied by *Hyla proboscidea* Brongersma (Zool. Anz., Bd. 103, Heft 9/10, 1933: 267–270). In consequence I propose *Hyla dalquesti* as a new name for this species, in honor of Mr. Walter W. Dalquest, who discovered the species.

The caption for the figures published with the type was inadvertently omitted. This should read as follows: *Hyla dalquesti*. A. Type, ventral view, region of the vent. B. Lateral view of head. C. Dorsal view of type (slightly diagrammatic).—EDWARD H. TAYLOR, *Museum of Natural History, University of Kansas, Lawrence, Kansas*.

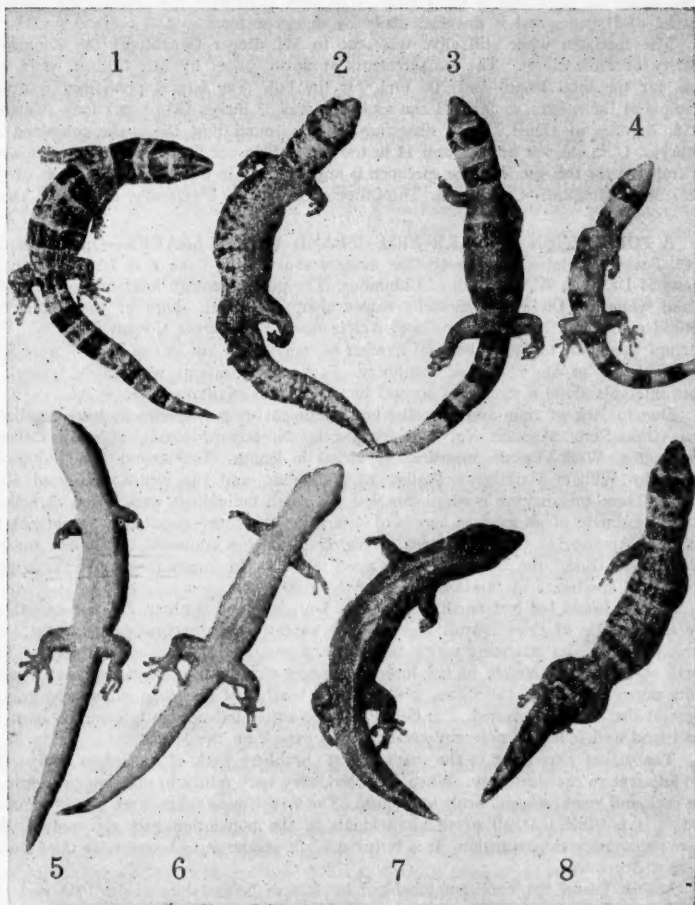
SEXUAL DICHROMATISM IN *SPHAERODACTYLUS STEJNEGERI*.—On September 18, 1948, I received a small lot of reptiles from Mr. Anthony Curtiss of Port-au-Prince, Haiti, with the following notes: "... they were collected at Hatte Lathan, which is a place on the Cul-de-sac Plain, a few miles from Damiens . . . in Sept. and Oct., 1947."

A cursory count led me to believe that the shipment contained 19 beautifully banded specimens of *S. stejnegeri* Barbour, representing two distinct patterns. Some corresponded to Dr. Cochran's description and illustration of the type, USNM 76640, and others to her description of the paratypes, USNM 60617 and MCZ 13481, wherein she makes no mention of the sex of the 3 specimens. As a consequence I assumed that the two patterns differentiated the sexes, but examination showed that none of these bore an escutcheon, which denotes the males in every species of *sphaerodactyl* which I have seen. Further examination revealed that a specimen of each pattern contained an egg and one specimen was intermediate in pattern. All patterned specimens were females.

In the preliminary sorting I had separated 14 uninteresting looking specimens for later identification. These bore a superficial resemblance to light colored *S. cinereus*. Upon examination all these turned out to be males, without pattern, but with a dark occipital area; the entire upper surface was light to medium brown due to minute specks on the scales; the underside clear cream color.

Of these Mr. Curtiss writes: "There is small brownish *sphaerodactyl* with orange throat and tail that we have thought to be male *cinereus*. They lose these colors in preservative. You will find some of these in this batch." It seems possible that some museum collections may contain males of *S. stejnegeri* among their *S. cinereus*. An easy way of distinguishing them is that the branches of the escutcheon stop halfway to the knee in *S. stejnegeri*, but continue to the knee in *S. cinereus*.

Among the 19 banded specimens, one is half-grown and appears to be a female, but 5 specimens are only 2 cm. long s-v, and although none has an escutcheon visible it appears probable that one or more may be young males in which case the series of 33 would contain 17 females and 16 males. It is my assumption that males and females hatch with the same banded pattern; that males lose their pattern entirely and that females mature before the banded pattern adds the speckled area between the bands that denotes fully patterned females.



Sphaerodactylus stejnegeri. Figs. 1, 2, 3, 4, 8 females. Figs. 5, 6, 7 males. 1, adult female showing inter-band pattern. 2, lower side of same pattern as 1. 3, mature, but apparently not fully patterned female. 4, lower side of same pattern as 3. 5, 6, lower side of males. 7, upper side of male. Note dark occipital area. 8, similar to 1.

Sexual dimorphism in which the male loses all pattern and becomes plain exists also in *S. roosevelti* Grant, of Puerto Rico, and *S. parkeri* Grant, of Jamaica, but these two bear no other resemblance to *S. stejnegeri*.—CHAPMAN GRANT, 2970 Sixth Avenue, San Diego 3, California.

A LARGE SPECIMEN AND A HIGH EMBRYO COUNT FOR THE QUEEN SNAKE.—On the slate flats of the Auglaize River, near the city of Defiance in northwestern Ohio, I have observed the queen snake, *Natrix septemvittata* (Say), to be a very abundant reptile. But, during three years of collecting in the area I do not recall having seen a single individual out in the open; all were taken from under rocks and other debris near the water's edge. The only exception was an unusually large female that was found sunning herself on the bank near a path along the stream. The date was June 18, 1946, when the river was in flood stage. The path is situated just outside the business district of Defiance and is traversed daily by many people.

The specimen while still alive was sent to Mr. Roger Conant, of the Zoological Society of Philadelphia. The measurements at death, taken by Mr. Conant, were 922 mm. for the total length and 206 mm. for the tail. The largest previously recorded example of the species, so far as I can ascertain, was 33 inches (838 mm.) long (Conant, 1938, Reptiles of Ohio). Upon dissection, it was found that the snake contained 23 embryos, 11 in the left oviduct and 12 in the right. I do not find a record of more than 11 embryos for this species. The specimen is now No. 696 in the reptile collections of the Ohio State Museum.—CHARLES A. TRIPLEHORN, *Ohio State University, Columbus, Ohio.*

A POPULATION OF LAKE ERIE ISLAND WATER SNAKES.—On August 30, 1945, I was a member of a party that made a tour of the Lake Erie Island region as guests of Dr. John W. Larcomb of Columbus. The party spent an hour or so on Middle Island, Ontario. On some limestone ledges along the north shore of the island, we noticed many very large individuals of *Natrix sipedon insularum* Conant and Clay. No attempt was made to count the total number of individuals, but in one place 7 were seen in the shelter of one clump of shrubbery. Such concentrations were fairly typical at close intervals along a stretch of several hundred yards of shore.

Due to lack of time and of collecting equipment only 2 specimens were captured. One (Ohio State Museum No. 698), caught by N. Bayard Green, Marshall College, Huntington, West Virginia, measured 49 inches in length. The second (No. 697), obtained by William Harrington Walker of Columbus, and the writer, measured 50¾ inches. These snakes were random samples. No small individuals were noted. I believe that an estimate of an average length of 4 feet for the entire population would not be extreme. Among 723 Ohio specimens of *Natrix s. sipedon* examined by Conant for his "Reptiles of Ohio," the largest one measured totaled 47½ inches in length; the largest among 413 specimens of *insularum* reached only 40 inches.

Middle Island lies just north of the U. S. boundary and is about 2½ miles south of the southern tip of Pelee Island. It extends in an east-west direction and is about 1300 yards in length. Its maximum width, near the east end, is approximately 330 yards. The north shore consists largely of the limestone ledges already mentioned, while the south shore slopes gently into the water, with frequent beaches of limestone rubble and gravel. Most of the island is forested. Dr. Green and the writer independently explored most of the island and failed to note any water snakes except on the ledges.

The snakes were lying in the shade of the shrubbery back of the ledges and in the sun adjacent to the shrubbery. When disturbed, they took refuge in numerous crevices in the rock and were rather difficult to capture. The 2 specimens taken were gravid females, and it is possible that all of the individuals in the population had gathered at this place preliminary to parturition. It is rather difficult otherwise to account for the absence of small specimens.

Middle Island has not been inhabited by human beings since about 1933 and the buildings on it are occupied only during occasional inspection trips by a caretaker. The island is not otherwise visited except sporadically by fishermen or other persons who may pass near its shores. The population of snakes may represent the size normally attained in the absence of persecution.

The 2 specimens were sent to Mr. Conant for study. He writes that he found that one contained 57 embryos, the other 25, the former number being the largest he has ever found in a snake of the genus *Natrix*.—EDWARD S. THOMAS, *Ohio State Museum, Columbus, Ohio.*

NOTES ON EGGS AND YOUNG OF THE LIZARD *RHINEURA FLORIDANA*.—Several years ago Doctor Thomas Barbour casually mentioned to me that Samuel Garman, formerly curator of reptiles and amphibians at the Museum of Comparative Zoology, had told him that very young specimens of the blind amphisbaenid, *Rhineura floridana*, have eyes. Although not a particularly astonishing revelation this was apparently an observation that had not been reported elsewhere and I went to some effort to authenticate it. In this I failed completely; no single truly infantile *Rhineura* was to be found in any available collection. In answer to my query as to the possible fate of the specimen on which Garman had based his statement Doctor Barbour wrote as follows:

Garman told me that he once had a young *Rhineura*. I think he said he got it from George Baur. Where Baur got it the opponent knoweth not. In any case one day when Cope was visiting the M. C. Z. Garman remarked on the presence of the eye in baby *Rhineuras*, showed the specimen to Cope and never saw it again. I suppose he turned his back for a second. It didn't usually take much longer than that for Cope to get away with anything smaller than a whale.

Meanwhile, I ransacked the Garman bibliography and disinterred some further data in an article entitled "Notes on certain reptiles from Florida and Brazil," which appeared in the *Science Observer* for 1883 (4: 47-48). The remarks on *Rhineura* are here quoted in full.

Four specimens of this species from Port Orange, Florida, have the number of folds on body and tail as follows: 242-17, 254-16, 257-15, and 261-18. Two others from Florida have 253-17 and 258-18 respectively. In the young the eye is visible; in the large it can not be detected. In a small specimen it is to be seen at the suture, between the upper angle of the hinder labial and the temporal, in the acute anterior angle of the latter. Its distinctness in the young suggests the possession of sight in the more helpless stages, or, possibly before the creature has located himself permanently—a faculty of which the species is more or less completely deprived later in life. Besides this, it is to be taken as evidence of the derivation of the species from others in which the eye was well developed. The position of the organ, at the junction of several plates, favors this idea.

On September 12, 1943, while digging a garbage pit behind my house in a hammock north of Gainesville, Florida, I uncovered 2 full term, and possibly hatching, eggs of *Rhineura*. The eggs turned up in a spadeful of sandy loam taken from a depth of between 20 and 50 centimeters. That the 2 eggs made up an entire clutch seems probable, since I immediately sifted several cubic feet of the surrounding soil through a ¼-inch mesh screen and found no additional eggs or shells.

Because both eggs were broken when I noticed them it is impossible to say whether or not natural hatching had begun. However, the jar of the fall was sufficiently strong to release both hatchlings, not only from the confining shells, but from whatever attachment had existed between them and a considerable amount of yolk that remained within the shells. The little lizards appeared to be uninjured and even made feeble efforts to burrow. They were in all respects similar to the adult except that the color in life was purplish white (instead of opalescent lavender and pink), the upper surface of the tail lacked the characteristic callous, and small but readily discernible eyes were visible beneath the scales.

The 2 specimens were killed and preserved a few hours after hatching. They have the following dimensions (in each case the measurement of the smaller specimen is given first; all measurements are in mm.): length 85, 103; distance from tip of snout to yolk scar 55, 75; tail 8.5, 9.2; width of head 3.5, 3.6; distance from tip of snout to eye 3.0, 3.1.

A restoration of one of the collapsed egg shells, which I believe represents the proportions of the unbroken egg quite closely, was made. The egg is remarkable in its extreme narrowness, the restored diameter being 8.9 mm. while the length is 38 mm. The shell is exceedingly thin, almost like rather tough tissue paper, and its surface is minutely granular, with a frosted appearance.

One of the specimens was presented to Doctor Rainer Zangerl of the Chicago Natural History Museum. The other is in the collection of the Department of Biology, University of Florida.—ARCHIE CARR, Department of Biology, University of Florida, and Escuela Agrícola Panamericana, Honduras.

THE STATUS OF *HYLA FLAVIGULA*.—Some tree-frogs from Texas described as a new species, *Hyla flavigula* (Glass, 1946, *Herpetologica* 3: 101), seemed to me obviously related to *H. squirella*. Through the courtesy of Dr. W. B. Davis I have been able to examine the type and paratypes of *flavigula*; and Dr. B. P. Glass provided a topotype and a specimen from Highlands, Harris County, Texas. These were compared with 54 specimens from Richmond County, Georgia, and with smaller series from scattered points in Georgia, South Carolina, and Florida. The western specimens can not be distinguished from eastern *squirella* on the basis of head shape, profile, body build, vomerine teeth, tongue, choanae, epidermis, webbing, or proportionate measurements involving snout-vent length, leg length, fourth toe length, interocular distance, internasal distance, eye diameter, tympanum diameter, head length, and head width. The supposed diagnostic coloration of *flavigula* is typical of breeding *squirella* throughout its range. The western specimens average slightly smaller than eastern ones, but no combination of characters will distinguish the two populations with any degree of certainty. *Hyla flavigula* Glass is therefore to be relegated to the synonymy of *H. squirella* Latrielle.—WILFRED T. NEILL, *Department of Biology, Augusta Junior College, Augusta, Georgia.*

NOTES ON THE TIMBER RATTLESNAKE AT MOUNTAIN LAKE, VIRGINIA.—During the period July 22–August 24, 1946, while at the Mountain Lake Biological Station of the University of Virginia, I obtained data on 19 specimens of the timber rattlesnake, *Crotalus horridus horridus* Linnaeus, 10 taken during the last nine days of July, the remaining 9 through the first twenty-four days of August. Only once were 2 rattlers, male and female, taken together. The smallest specimen was a 38-inch male, the largest a 48-inch female. A 44-inch female, collected August 18, contained 9 fully developed eggs that showed practically no signs of embryonic development.

Of the 19 examined, 12 specimens contained food remains, varying from a complete animal in the stomach to only small amounts in the lower intestinal tract; usually only 1 animal was recognizable. In some 2 specimens of the same species were found; and one contained 3 food animals, representing 3 species, a lemming, a long-tailed shrew, and a white-footed mouse. In 2 snakes in which the stomach and intestines were devoid of food, a small reddish mucous-like mass as thick as a lead pencil was located near the lower end of the intestinal tract. In the center of one of these masses there was a single fang, while two fangs were found in the other.

The food of the 12 rattlers was exclusively mammalian. Remains of mice were found in 11 of the specimens (per cent of frequency of 91.6) and of these, as was expected, the majority were white-footed mice (*Peromyscus*), occurring seven times (per cent of frequency of 58.3). The greater part of a chipmunk (*Tamias striatus fisheri*) was recovered from 1 specimen. The one shrew obtained, skull included, was a specimen of *Sorex cinereus cinereus*, which was less common in the region than *Blarina brevicauda*, the short-tailed shrew.

Peromyscus leucopus novboracensis and *P. maniculatus nubiterre* were about equally represented. Remains of 2 white-footed mice were merely identified to the genus *Peromyscus*. The following additional species were recorded: one red-backed mouse (*Clethrionomys gapperi* cf. *maurus*), 2 woodland jumping mice (*Napaeozapus insignis*), and 1 bog lemming (*Synaptomys cooperi stonei*). The record of the latter is of special interest as this lemming has not often been reported from Virginia, and trapping for two days had failed to produce a specimen. Although traps were set especially for jumping mice, and one was actually seen among a group of traps, the only specimens obtained were the 2 caught by the rattlesnakes.

Dr. Ivey F. Lewis, Director of the Station, called my attention to a large specimen of the Allegheny wood rat (*Neotoma magister*) in the Station Museum, that had been taken from the stomach of the only rattlesnake killed on the cleared ground about the Station, during the first season the Station was open.

These notes supplement the paper by F. M. Uhler, C. Cottam and T. E. Clarke (1939, Food of snakes of the George Washington National Forest, Virginia; *Trans. Fourth N. Am. Wildlife Conf.*: 605–622), in which they include data on 141 food-containing stomachs of rattlers—THOMAS SMYTH, 126 E. Garfield St., Shippensburg, Pennsylvania.

OBSERVATIONS ON THE SALAMANDER *DICAMPTODON*.—The western marbled salamander, *Dicamptodon ensatus* (Eschscholtz), in the larval stage, is a common resident of the streams of the Pacific Northwest from northern California to northern Washington. A fisherman who fishes these streams sooner or later hooks one of these salamanders, as they take live bait of all kinds. On the north fork of the Santiam River I have taken them on salmon eggs behind a spinner, on bucktail flies and on wet flies. The procedure was to locate the salamander on the bottom of the clear deep pools where they like to rest. It was necessary then only to drop the bait in front of the salamander. Live worms, salmon eggs, or meat dropped up stream from the resting salamander would bring it to the bait. If the bait was resting it was taken leisurely. If it was moving, it was usually taken with a rush and a vigorous snap. Artificial flies were taken when floated within 10 to 12 inches of the salamander and were always taken with a quick rush. The reaction time of the larval form and particularly of the terrestrial form is surprisingly fast and vigorous for an otherwise phlegmatic and slow moving animal. The terrestrial form particularly has the habit of snapping its body in a lightning-like strike sideways when taking a moving bait. As a boy I took this salamander in the larval stage



Fig. 1. *Dicamptodon ensatus* with head of gartersnake in its jaws.

quite frequently on worms while still-fishing on Muddy Creek, in Benton County, Oregon. The strength of the jaws of this salamander is well demonstrated in that most specimens taken with a hook and line grip the bait and hook so tightly that the hook is not set in the flesh of the mouth when they are jerked out of the water. After a few moments on dry land they release the bait and hook and waddle off towards the water. Worms and aquatic larvae of insects and probably some small fishes and other aquatic forms of life are their chief foods.

Indications are that the mature, terrestrial form of *Dicamptodon* is even more voracious than the aquatic larval stage. Mature *Dicamptodon* to date have been a rare item in the bag of Oregon collectors. I believe that if collectors will work the heads of the very small mountain streams in the big timber areas during the dry months when the streamlets are reduced to a trickle, more mature *Dicamptodon* will come to light. I have turned up two mature specimens in such a situation, both buried under the coarse gravel at the foot of a small pool of a small stream. The larval specimens in this pool and others nearby were all in the last stages of transformation to the terrestrial form. This was on the west side of Grass Mountain, Lincoln County, Oregon. The streamlet was typical of the area, being reduced to a trickle that disappeared at intervals in the

gravel, with small pools dammed up occasionally behind some large rocks. Vine maple, salmonberry, and alder formed a complete canopy overhead.

Several *Plethodon vehiculus* kept in the same jar with specimens of *Dicamptodon* were eaten. One of these was a mature 4-inch specimen. While this is perhaps unusual, it is not extraordinary as compared with some ventures of *Dicamptodon* in capturing food. J. S. Diller (1907, Science, [N.S.] 26: 907-908) gives an interesting account of a gartersnake and a marbled salamander locked in combat, from an incident observed in Douglas County, Oregon. It was evident that the salamander was the captor and the snake the victim. Even more extraordinary was the fact that the salamander was a normal 8-inch specimen, while the snake was a mature gartersnake fully 2 feet long. Mr. Diller states: "The salamander was found to have a firm grip on the snake at the base of the right jaw and neck. The snake could not bite the salamander, but writhed so as to turn him over and over and drag him along on his sides and back without affecting the grip of the salamander." Extraordinary as this incident may appear it is not an isolated one. I observed an almost identical struggle in its last stages. Unfortunately, as in Mr. Diller's case, it was not possible to witness the closing action of the drama and to see what the salamander would try to do with its oversized victim.

On July 3, 1941, about 6:30 P.M., while returning from photographing a murre colony on Cape Lookout, I came upon a northwestern gartersnake (*Thamnophis ordinatus concinnus*) gripped in the jaws of a mature *Dicamptodon*. This was on the Cape Trail where it enters the heavy spruce and hemlock timber, which covers most of the Cape. The gartersnake was of average size, about 25 inches in length, and apparently in good physical condition. The salamander, also an average adult, measured about 7 inches in length. The salamander had a solid grip on the snake's head just behind the eyes. The snake was completely helpless and could only squirm and wriggle feebly and was barely able to move the salamander in its efforts to free itself. It was apparent that the struggle had been going on for some time and the strength of the snake was almost spent. I took several pictures of the combatants as they were found, as I feared that the salamander might let go if disturbed by attempts to move into better light. After the initial pictures were taken, I decided to move them, for photography in the lengthening shadows was somewhat uncertain. The snake was picked up by the tail, and with the salamander tightly clamped to his head, was moved to a more favorable position. This and subsequent handling did not seem to disturb or excite the salamander. Once, after having been moved, the salamander changed its grip slightly. This it did by a lightning-like snap of its jaws, regripping the snake about a half inch farther back. The snake's head was squeezed flat without actually crushing it, and its lower jaw was folded back beneath the head. This latter condition arouses the interesting conjecture of who attacked first, the snake or the salamander? From the position of the snake's jaw it would seem that the snake had attacked first, that is, it had struck, its jaws set wide for a grip, but had been met literally head on by the salamander's strike. From the previously mentioned reflex reaction of *Dicamptodon* it can readily be imagined how the salamander struck at the movement of the snake's head and that its own greater capacity and strength rendered the snake helpless. It is not likely that the salamander had gripped the snake in any other hold than that which was at first observed and had later shifted its grip to that position. Under those circumstances, the salamander's soft skin would have probably received numerous lacerations from the fine, sharp teeth of the snake. Once on the log on which the pair were placed, the snake was able to gain purchase with its scales in the cracks of the rotten wood and slowly pulled the salamander with it. The salamander made no effort to resist, but followed passively along, maintaining its tight grip. It obviously had insufficient power to crush the snake's tough, pliant head.

While I was debating what to do with the combatants, the salamander suddenly released the snake, which glided slowly into the underbrush, plainly showing a rather awry and dislocated lower jaw.

A smaller and less rugged victim would have fallen a ready prey to the salamander, and I have no doubt that a deer mouse or shrew would be handled with little difficulty since the jaws are amply wide and strong enough to crush the life out of such a small mammal. It was unfortunate that it was not possible to leave the salamander undisturbed and observe the disposition of the dead snake, for there is no doubt in my mind that the snake would have perished in a matter of an hour or two.—WILLIAM GRAF, Department of Zoology, San Jose State College, San Jose 14, California.

THE PROBLEM OF METAMORPHOSIS IN THE WESTERN MARBLED SALAMANDER *DICAMPTODON ENSATUS*.—The smallest specimen of a metamorphosed *Dicamptodon ensatus* known to me, collected near sea-level on the bank of a small branch of Fogarty Creek, three-quarters of a mile south of the Lincoln Beach post office, Lincoln County, Oregon, on April 13, 1946, had a total length of only 96.5 mm., of which the tail was 39.0 mm. The gonads were immature and the sex was not determined. Five larvae collected the same day from tiny pools in the trickling creek had lengths as follows (mm.): 77.5, 64.0, 46.0, 43.5, and 42.0. The three smaller of these agree in size with a series of first-year larvae captured in April in Marin County, California, by Kessel and Kessel (1943, Wasmann Coll., 5: 108–111), but the larger two are more nearly the size of those caught in July in that part of California.

The previously reported size range for metamorphosed individuals of this species is from "nearly 300 mm." (Bishop, 1943, Handbook of Salamanders: 176) to 105.0 mm. (Kessel and Kessel, 1944, Wasmann Coll., 6: 38–48). Larvae as large as 286.0 mm. have been found (Bishop, *loc. cit.*), and Graf, Jewett, and Gordon (COPELA, 1939: 101–104) have suggested, on the evidence of the mature condition of the gonads, that some of these larger larvae not only may breed, but perhaps may never metamorphose.

Dr. L. E. Griffen (Reed College, Portland, Oregon), who has collected many specimens of *Dicamptodon*, has stated (personal communication) that, in the middle part of the Oregon coastal mountains, he has never found an individual, either larval or adult, larger than approximately 110 mm. This area includes the locality where the 96.5 mm. specimen was collected.

In their excellent study of this animal in Marin County, California, Kessel and Kessel (1943, Wasmann Coll., 5: 108–111, 141–143; 1944, 6: 38–48) found that in nature metamorphosis typically occurred during mid-summer of the second year as the larvae reached lengths between 130–140 mm. In the laboratory, animals of this size remained in the larval condition only so long as they were denied shallow water, but metamorphosed in a few days when this was provided. From this evidence, Kessel and Kessel suggested that possibly larvae larger than 140 mm. may develop in the deeper creeks with high banks, or during years of exceptionally heavy rains. This tentative conclusion does not explain the diminutive individuals in the Oregon coastal mountains, a region of heavy rainfall, nor does it explain the 270 mm. larva collected by the writer in March, 1944, on the Eastmoreland Golf Course, Portland, Oregon, in a permanently shallow stream with low banks.

Considering these facts, and considering that metamorphosis and the attainment of sexual maturity in *Dicamptodon* are not necessarily correlated, there is need for an investigation into the factors concerned with metamorphosis in this genus over the whole of its geographical range. Among these factors would be the varied environmental conditions, larval and adult size distribution, and thyroid metabolism (possibly related to iodine concentration in the streams of the different areas).—CHARLES A. REED, *University of Arizona, Tucson, Arizona*.

EXTENSION OF THE RANGE OF THE DESERT NIGHT LIZARD.—According to Smith (1946, Handbook of Lizards: 330) *Xantusia vigilis* Baird is found only as far north and west, in relation to the Coast Range chain, as Fort Tejon, Kern County, California, which is the type locality of the species. On October 17 and 18, 1947, several specimens of the night lizard were obtained about 2 miles south of where the Panoche Pass road crosses the San Benito County-Fresno County boundary line. This was at an elevation of 1500 feet. The range of the night lizard thus would be extended about 150 miles airline northwest of the recorded limits. The specimens were found under the dead remains of *Yucca whipplei*. This stand of the yucca is probably the most northern one in the Coast Range as Jepson (1925, Manual of the Flowering Plants of California: 246) states that San Benito County is as far north as this species comes, and I have not seen it north of this area. If, as is intimated by Smith and others, the lizard is intimately associated with yucca, this is probably its northern limit in the inner Coast Range. Reported intervening stands of yucca between this point and Fort Tejon would indicate sufficient, though possibly interrupted, habitat for the species through this area. Five specimens, including one small one, secured in less than one hour's work, indicate that the lizard is relatively abundant at this point. The examination of other stands of yucca

bordering the San Joaquin Valley might disclose yet other stations for this lizard.—
ALBERT C. HAWBECKER, *Fresno State College, Fresno, California.*

REVIEWS AND COMMENTS

STUDIES IN FRESHWATER FISHERY BIOLOGY. By Karl F. Lagler. J. W. Edwards, Ann Arbor, Michigan, 1949: v + 231 pp., 8½" x 11", numerous illustrations including 50 halftones. Third revised edition. \$4.00.—Dr. Lagler's manual, developed as an aid in teaching fishery biology at the University of Michigan, is rapidly becoming a polished and very useful work, both for teaching and as a reference for fish managers. This third edition is attractively printed on good paper and well bound. The book is a series of outlines for study of fishery literature, fish identification, and fish anatomy and life history with an expanded section on age and growth; also fishery inventories and management, including fish population estimates, creel census, parasites and diseases, pollution, fish culture, lake and stream surveys and improvements, and other subjects. Each of the many chapters is concluded by a list of references to the particular subject. The many halftones add much of interest in the manual. The substance of the book is focused somewhat on Michigan and the Great Lakes region, yet it is generally applicable to fishery biology in North America.

THE FRESH-WATER FISHES OF BRITISH COLUMBIA. By G. Clifford Carl and W. A. Clemens. British Columbia Provincial Museum. Handbook No. 5, 1948. 172 pp., 7 color plates (of trout) and numerous black and white illustrations.—This is a key and a brief account of the "sixty-three different kinds" of fishes in fresh waters of British Columbia. Introductory essays on fish environment, structure, distribution, and economic importance are followed by a family key, and then an account of each family which includes a key to the species and notes on distinctive characters, geographical distribution and life history of each. There is a glossary to technical terms and a very useful bibliography on fishes of the northwest.

THE IMPORTANCE OF UPWELLING WATER TO VERTEBRATE PALEONTOLOGY AND OIL GEOLOGY. By Margaretha Brongersma-Sanders. Trans. Royal Netherland Academy of Sciences, Section of Natural History (Second Section), 45, No. 4, 1948: 112 pp.—The article deals with the mortality of fish and other organisms in Walvis Bay of southwest Africa, and the author concludes that in this and similar coastal areas throughout the world where upwelling of ocean water is of frequent or regular occurrence the mortality is caused by "red water" (dinoflagellate) poisoning. The history of fish mortality at Walvis Bay is reviewed, as well as the geographical coincidence of upwelling water, "red water," and mass fish mortality in particular coast line areas throughout the world. The author gives an extensive bibliography.—GERALD P. COOPER, *University Museums Annex, Ann Arbor, Michigan.*

BIBLIOGRAPHY OF ANIMAL VENOMS. By R. W. Harmon and C. B. Pollard. University of Florida Press, Gainesville, Florida, 1948: xxx + 340. \$8.00.—Harmon and Pollard list 4,157 titles (with a few duplications) in their venom bibliography. These apparently have been copied from abstracting journals and indexes of scientific literature since in almost every item two or more references are given, one to the article and one or more to an indexing or abstracting journal. In the case of books this same system has been followed. A key to periodical abbreviations and an index of authors are included. Each title has received a number. The primary order is chronological but under each year the titles are arranged alphabetically by authors. The year 1875 has one title, 1877 has two; after this, the number per year rapidly increases.

Taking a broad interpretation the authors have included papers on all conceivable aspects of their subject and many general books on groups of venomous animals. No comprehensive work on poisonous animals and their poisons has appeared since 1922 (Phisalix: Animaux venimeux et Venins) nor has any extensive bibliography of the subject appeared, so that the present volume is fully justified. Its format is good.

By way of adverse criticism it must be pointed out that chronological arrangement of titles is an exceedingly unfortunate one because it forces almost every user to read all the titles. It would have been inestimably better to classify the titles by subject heads because nearly all of them readily fall into simple categories such as insect, arachnid, amphibian or reptile venoms. Even an alphabetical-by-author arrangement would have been an improvement. Many titles could have been omitted; for example, No. 3183, a paper on respiration of the egg and young of a harmless snake. Giving the reference to the abstracting journal is advisable only when an abstract can be found, which often is not the case even in an abstract journal, title No. 2370 for instance. Certainly there is no excuse for the innumerable references to mere indexes. The completeness of any bibliography is hard to gauge but the present one cannot be nearly complete. This fact is not pointed out in a critical sense but merely to caution users who might assume that such a large bibliography is complete. The literature on animal venoms is vast and no bibliographer could be expected to bring it all together.—CLIFFORD H. POPE, *Chicago Natural History Museum, Chicago, Illinois*.

BOY'S BOOK OF SNAKES HOW TO RECOGNIZE AND UNDERSTAND THEM. By Percy A. Morris. New York, Ronald Press: viii + 185 pp., illus. \$3.00.—No publisher with a line of books on natural history can rest easily without one or more books about snakes on his lists. This produces a seller's market for MSS on snakes and snake lore, and I deduce that the publisher's need for the present work was greater than that of the public.

Mr. Morris' little introduction to snake lore is printed on such excellent paper that it is the more to be regretted that so many of his illustrations are from inadequate original photographs; some are fuzzy to the point of uselessness. The book is marred by minor misstatements, such as incorrect definitions of the "rings" and "buttons" of the rattlesnake rattle, and the statement that sea-snakes are oviparous (mostly being viviparous). The species figured as the green tree boa, which is correctly described in the text, is another species of boa. The junior author of the "Field Book of Snakes of the United States and Canada" would like to know how Mr. Morris learned that his first name is Delbert.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago, Illinois*.

RUDIMENTARY MATHEMATICS FOR ECONOMISTS AND STATISTICIANS. By W. L. Crum. McGraw-Hill Book Company, Inc., New York, 1947: 183 pp.—This little book has as its objective "to present rudimentary ideas and operations essential to any effective mathematical reasoning by economists and statisticians.—It is directed to the mere beginner." Included are chapters on graphic analysis, limits, rates and derivatives, maxima and minima, differential equations, and determinants.

Biologists will find it difficult because the data and situations used for the frequent examples are entirely from the field of economics. The concepts such as prime cost, production, function, marginal utility, profit, and investment probably will not help the non-economist to understand the mathematics. Other elementary texts such as "Calculus Made Easy," by S. P. Thompson, are better for the biologist.—W. F. ROYCE, *U. S. Fish and Wildlife Service, Woods Hole, Mass.*

EDITORIAL NOTES AND NEWS

Pacific Oceanic Fishery Investigations¹

IN 1947 the Congress authorized the exploration, investigation, and development of high seas fisheries of the Territories and island possessions of the United States in the tropical and subtropical Pacific Ocean and intervening seas. On July 1, 1948, funds for these purposes became available by Congressional appropriation.

The activities authorized will be carried out by a unit within the Fish and Wildlife Service to be known as PACIFIC OCEANIC FISHERY INVESTIGATIONS. Appointments have been made of OSCAR E. SETTE, Director; FRED F. JOHNSON, Assistant Director; MILNER B. SCHAEFER, Chief, Section of Biology and Oceanography; CARL B. CARLSON, Chief, Section of Exploratory Fishing; and CHARLES BUTLER, Chief, Section of Technology. A temporary headquarters office is now located in Room 811, Appraisers Building, 630 Sansome Street, San Francisco 11, California.

Permanent headquarters for this activity will be a laboratory to be erected on the University of Hawaii campus in Honolulu. Three vessels will be operated—two of these are former Navy Y.P.'s of the 600 class which are 128-foot wooden vessels of the tuna-clipper type driven by 560 H.P. direct drive diesels. One of these will be fitted out for practically full scale live-bait fishing operations with circulating water in the deck bait tanks and four below-deck wells. Deck arrangements will be adaptable also to long-line operations. There will be sufficient refrigeration capacity for about 100 tons of tuna. The quarters will be re-arranged to provide a small laboratory and staterooms for several scientists and technicians. The other, while retaining some of the live-bait tanks and refrigerated hold space, will be designed primarily for oceanographic and biological research. She will mount three winches: one for Bathythermograph casts, one for hydrographic casts, and one for towing plankton gear and small nets. It is planned to provide this vessel with a small auxiliary driving unit with an independent motor, shaft and propeller for proceeding at low speed while hauling plankton gear. The third vessel is a 100-foot steel seiner-dragger type vessel formerly owned by the United States Reconstruction Finance Corporation and operated by the Pacific Exploration Company. She will be fitted out primarily for purse-seining and secondarily for gillnetting. All three vessels will have ample fuel, water, and stores capacity for operating at great distances from their base at Honolulu without frequent stops for refueling and reprovisioning at outlying island ports.

First year's funds and attention will be concentrated largely on the vessel, laboratory, and dock site construction projects. Simultaneously several reconnaissance projects are to collect information to guide the development of the program when facilities are ready for operations. Arrangements are underway for one team to be detailed to work out of SCAP headquarters in Tokyo under Wm. C. HERRINGTON, chief of the fisheries division of the Natural Resources Section, to collect scientific and technical data on Japanese fishing and fishery research operations in the former Japanese-mandated island areas and to observe Japanese fishing operations at first hand. Another will operate out of Honolulu, assembling information on tunas and bait species along the leeward chain to Midway and south along the Line Islands to Jarvis Island.

When the vessels are ready, probably late next spring, they will have several months shakedown operation in the vicinity of the Hawaiian Islands. Following that, they will embark on the major program, either in the same area or elsewhere, depending on the findings of the reconnaissance projects.

While the detailed plans for the major program and the areas to be covered will not be determined until information is in from the reconnaissances, some general features of the course to be followed can now be announced.

The activities of all three ships are to be co-ordinated so that exploratory fishing for the various pelagic species in the various areas will be possible by the usual methods of fishing such as live bait, purse seine, long line, and gill net as well as combinations

¹ Published by permission of the Director of the United States Fish and Wildlife Service.

and modifications of these, together with certain oceanographic and biological observations to throw light on the particular ecological situations in which the fish are present or absent. At the same time the research vessel is to survey the distribution of physical, chemical, and biological properties of the general sea area in which the exploratory fishing is conducted. It is expected such co-ordinated activities will enable the availability of fish to be examined against an ecological frame of reference that will suggest some fundamental laws of horizontal and vertical distribution, migration, aggregation, and feeding. The same field activities also can be expected to yield information on life history and related subjects—as yet an almost unexplored field as concerns the tunas.

The exploratory fishing and research activity will yield collections of specimens and of morphometric data for studying the systematic position of the various species of tuna and the micro-systematics of the various species. Museums have no extensive series of tunas available for studying these problems. Since suitable material is a prime essential, a start has already been made toward assembling a reference collection, eventually to be housed in the new Honolulu laboratory. Since this subject is not only of intrinsic interest and basic to all phases of the ecological program, but is also of great significance in the international exploitation of high-seas fisheries, it will receive major attention in the program.

While there are a number of pelagic species of fish of large size in the area of these investigations, it appears that the yellowfin tuna, *Neothunnus macropterus*, and skipjack, *Katsuwonus pelamis*, offer the greatest promise of forming the basis of a large commercial fishery. The investigations will, therefore, be concentrated on these. However, other pelagic fishes present in important numbers in the region of study may be of potential commercial importance, and will receive their share of attention. These include such fishes as the black skipjack, *Euthynnus yaito*, the dogtooth tuna, *Gymnosarda nuda*, various Cybiidae and the swordfishes and marlins.

The Territorial Division of Fish and Game of Hawaii and the University of Hawaii have interest in and facilities for research on Pacific fishery problems. It is planned not only to design the program of Pacific Oceanic Fishery Investigations so that the work of the three organizations may be mutually supplementary but also to enter into direct collaborative activities where opportunity affords. It is expected also to utilize opportunities to co-ordinate observations with those of the Hydrographic Office's Division of Oceanography, the various state fishery agencies on the Pacific mainland coast and with such marine research activities as may take place under the auspices of Pacific War Memorial.—OSCAR E. SETTE, *Pacific Oceanic Fishery Investigations, Room 807, 630 Sansome St., San Francisco 11, California.*

British Herpetological Society

THE BRITISH HERPETOLOGICAL SOCIETY, organized in 1947, has distributed the first number of the British Journal of Herpetology (June, 1948) devoted to a comprehensive report on the distribution of reptiles and amphibians in Great Britain and Ireland by R. H. R. TAYLOR.

MR. ALFRED LEUTSCHER, the Secretary, writes that "The purpose in founding the British Herpetological Society is to bring together all those interested in the study of reptiles and Amphibia, with a view to increasing our knowledge in this field. Scientific work in anatomy, physiology, genetics, and taxonomy, etc., is encouraged, but the importance of study in general natural history of these animals (e.g., behaviour, hibernation, feeding, and breeding habits) as well as distribution and field work in ecology is particularly stressed. Much observation of this kind is still needed. It is felt that in a Society of this kind there is ample room for both amateur and professional worker. The British Herpetological Society is the first serious organization of its kind in this country and is receiving most encouraging support."

The annual dues, which include subscription to the journal, are 10 shillings. Correspondence regarding membership or subscription, at 4 shillings per number, may be addressed to MR. LEUTSCHER at the British Museum (Natural History), Cromwell Road, London S.W. 7, England.

The current officers of the Society are MALCOLM SMITH, President, ALFRED LEUTSCHER, Secretary and Treasurer, ANGUS D'A. BELLAIRES, editor, together with H. W. PARKER and HELEN SPURWAY.

COPEIA welcomes the sister journal and expresses the hope that it may have a long and useful life.

News of Stanford Ichthyologists and Herpetologists

THE "Survey of Brazilian Marine Fishes of Commercial Importance," a joint project of the Museu Nacional, Rio de Janeiro, and the Stanford Natural History Museum, and designed to provide a basis for commercial catch records at Brazilian ports, is progressing actively at Stanford. The work was begun by PROF. GEORGE S. MYERS in Brazil in 1943 and is continuing under his direction. MISS L. V. SMITH, formerly of the Philippine Dept. of Fish and Game, is associate ichthyologist of the Survey, and MR. R. R. HARRY, JR., has acted as part time assistant ichthyologist. MISS ALBA ALBUQUERQUE MARANHÃO, formerly of the Museu Goeldi in Pará, who has recently arrived in this country on a Fish and Wildlife Service fellowship, will take part in the work.

Graduate students who are working on ichthyological or herpetological problems with Prof. Myers include: CLARK HUBBS (revision of Pacific Coast clinid blennies), WALTER C. BROWN (herpetofauna of the Solomon Islands), RICHARD G. MILLER (food habits of Lake Tahoe fishes), MARTIN R. BRITTON (revision of the cyprinid genus *Rasbora*), R. R. HARRY, JR. (Pacific paralepid fishes), ROBERT B. SANDERS (herpetology of Ventura County), and PATRICIA BARTON (catfishes of Cameroon).

Prof. Myers was invited to attend the Inter-American Conference on Renewable Natural Resources in September, 1948, and presented a paper on the management of freshwater fish resources in South America. He also attended the Seventh Pacific Congress in New Zealand in February, 1949, and presented papers on the biogeography of Pacific freshwater fishes and amphibians, and on the protection of rare and vanishing fishes.

PROF. WILLIS H. RICH is confining his university work almost entirely to the supervision of graduate students in fishery biology and giving part of his time to salmon research with the Fish and Wildlife Service. He spent the summer of 1948 in Alaska.

The Stanford *Fischverein*, an informal discussion group attended by Stanford fish students as well as almost all the professional ichthyologists and fishery biologists in the area from San Francisco to Monterey, continues to meet monthly during the school year. The group was formed by Prof. Myers in 1937 and meets at the houses of faculty and other members in and about Stanford and Palo Alto. From 30 to 40 usually attend the gatherings and colleagues visiting in the San Francisco area are especially welcome.

PROF. ROLF L. BOLIN, of the Hopkins Marine Station of Stanford University, in Pacific Grove, has recently returned after more than a year in Europe on a Guggenheim Fellowship. He visited most of the European museums, including Berlin and Vienna, to study types of lantern fishes, a group upon which he is making revisional studies.

Contributions to Dean Memorial Library

DR. E. W. GUDGER writes: "If the Ichthyologists of our Society would put the Bashford Dean Memorial Library of Ichthyology, American Museum of Natural History, New York 24, on their mailing lists, it would be a fine thing. Their reprints would be carefully preserved, bound up with other like articles, and shelved in the Dean Library for the use of members of the Department of Fishes and visiting scientists."

Cumana Fisheries Laboratory

THE SECRETARY transmits the following request from one of our members, MR. AUSTIN FERNANDEZ-YEPREZ, Laboratorio de Pesqueria, Apartado No. 11, Cumana, Edo. Sucre, Venezuela. The latter wishes to announce that he is now head of the Fisheries Laboratories at Cumana and desires to receive papers for the fishery library which he is attempting to build up. They urgently need papers on all fishery subjects, but especially on those of Atlantic fishes and the freshwater fishes of Central and South America.

Aid to Copeia

THE Editors acknowledge gratefully contributions from the TRACY I. STORER GIFT FUND, the ENDOWMENT FUND, and ROGER CONANT, which made possible the publication of the colored plate of the races of *Natrix erythrogaster*, and from E. ROSS ALLEN, for publication of the Florida map.

News
Notes

DR. ALFRED PERLMUTTER, formerly in charge of the northern New England fishery investigations of the United States Fish and Wildlife Service at Gloucester, Massachusetts, was transferred, in December, 1948, to the Great Lakes staff at Ann Arbor, Michigan, where he is in charge of the sea lamprey investigations for the Service.

Herpetological Editor KARL P. SCHMIDT, who flew to New Zealand in February to attend the meetings of the Pacific Science Congress, writes of his delight in his first pilgrimage to see the tautara in life. Through the kindness of Mr. Percy Carter he was put ashore on the sanctuary island of Karewa, 7 miles off shore in the Bay of Plenty, for two nights and a day of observation. "Just after dusk, after the burrowing petrels began to come in, two tautaras came out. They were excessively light-shy, and one retreated from my flashlight while the other escaped down hill, only to become entangled in my bed-roll. What a wonderful compensation for my failure, through twelve years of sleeping on the ground in our west, to catch a rattlesnake in my blankets!"

ALBERT W. C. T. HERRE, late consultant and ichthyologist for the Philippine Fishery Project, U. S. Fish and Wildlife Service, completed a checklist of Philippine fishes last year. The list contains 2145 species, with their synonymy, occurrence in the Philippines, and general distribution. Dr. Herre is now curator of fish collections in the School of Fisheries, University of Washington, Seattle 5, Washington.

DR. CARL L. HUBBS writes concerning recent developments in fish matters in California: "I finally hear from Paul Needham, indicating that he has accepted the Professorship of Zoology, for teaching and research in fisheries at the Berkeley campus of the University. The work that is being initiated there will give emphasis to the fish management problems that are related to the general fish and game program at the University. The companion development at the Los Angeles campus, being headed by Boyd Walker, is giving chief emphasis to marine fish and fisheries work. The Scripps Institution of Oceanography will continue and expand its program of fisheries research and the training of fisheries workers."

DR. C. V. KULKARNI, Superintendent of Fisheries, Department of Fisheries, Bombay, India, is currently visiting fisheries laboratories in this country.

RODGERS D. HAMILTON, Museum of Zoology, University of Michigan, returned to Ann Arbor in early December from an eight-months trip in Arctic Alaska, Yukon and Northwest Territories of Canada. He was studying the ecology and distribution of *Rana sylvatica* in the far north under an Arctic Institute of North America fellowship.

JAMES A. PETERS, Research Assistant, Division of Reptiles and Amphibians, Museum of Zoology, University of Michigan, left February 15 on a three- to four-month field trip in western Mexico.

The next annual meeting of our society will be held in Washington, D.C., June 18th to 21st, 1949. An announcement of headquarters and local committee has been sent out recently.

As COPEIA was passing through press, word was received that DR. SAMUEL F. HILDEBRAND died on the evening of March 16 in Washington, D.C. while teaching a Sunday School class.

Mailing
Dates for
Copeia, 1948

COPEIA for 1948 was entered as second class matter in the United States Post Office, Ann Arbor, Michigan, on the following dates: No. 1, April 22, 1948; No. 2, July 9; No. 3, October 10; and No. 4, January 6, 1949, according to records at the Ann Arbor Press.

LIST OF NEW MEMBERS

Added to the Society between October 13, 1948, and February 8, 1949.

Axtell, Ralph W., Box 386, Bishop, Tex.
Bell, Edwin L., 356 7th St., Northumberland, Pa.
Benson, Norman G., Wilcox Ave., East Berlin, Conn.

- Bishop, E. E., Palm Beach Jr. College, West Palm Beach, Fla.
 Black, E. G., 532 Anderson St., Greencastle, Ind.
 Byrn, John W., 118 Clark Ave., Billings, Mont.
 Chidley, P. F., 873 Palmerstone Ave., Toronto, Ont.
 Congdon, Mark H., P. O. Box 80, Charlottesville, Va.
 Dickerson, Richard H., White Plains Pet Shop, 6 Quarropas St., White Plains, N.Y.
 Darnell, Reznat M. Jr., Dept. of Zoology, Univ. of Minnesota, Minneapolis 14, Minn.
 Garner, William V., 447 E. Wadsworth St., Philadelphia 19, Pa.
 Goffery, James, River Avenue, Eastport, L.I., N.Y.
 Gottschang, Jack L., Dept. of Zoology, Stimson Hall, Cornell Univ., Ithaca, N.Y.
 Hackel, Emanuel, 1017 Oakland, Ann Arbor, Mich.
 Halpern, Myron H., Dept. Zoology, Dewey Bldg., Univ. of Rochester, Rochester 3, N.Y.
 Hawken, John L., 1541 Burlingame Ave., Burlingame, Calif.
 Hawthorne, Frank W., 1318 Minerva Road, Ann Arbor, Mich.
 Hedrick, Robert M., 258 E. Annapolis, W. St. Paul 7, Minn.
 Hertlein, Ronald, Box 217, Route 1, Bristol, Wisc.
 Howden, Henry F., 4409 Sedgwick Rd., Baltimore 10, Md.
 Isenberg, Carl, 2344 Webster St., Palo Alto, Calif.
 Knipping, Paul A., 101 Stock Pavilion, Dept. of Veterinary Science, Univ. of Wisconsin, Madison 6, Wisc.
 Martin, Paul S., Box 532, Westchester, Pa.
 Massmann, William H., Virginia Fisheries Lab., Yorktown, Va.
 Mathews, Robert S., 36 West 11th St., New York, N.Y.
 Merrell, Theodore R., 11355 Hamburg Rd., Hamburg, Mich.
 Mork, Yono, 1508 Eutaw Place, Baltimore 17, Md.
 Nelson, D. J., 729 Elm Drive, Billings, Mont.
 Oliva, Ota, Cermakova 8, Prague XII, Czechoslovakia.
 Parizy, R. M., 10 Rue D. Avron, Gagny Seine & Oise, France.
 Reilly, Edgar M., 305 East Veterans Place, Ithaca, N.Y.
 Robertson, James B., Box 434, Humboldt, Kan.
 Romer, J. D., % Medical Dept., Hongkong, China.
 Russert, Louise R., Miss. Dept. of Zoology, Univ. of Arkansas, Fayetteville, Ark.
 Sanders, Robert B., Natural History Museum, Stanford Univ., Stanford, Calif.
 Schroder, Robert C., 2012 S. Spring St., Springfield, Ill.
 Schwartz, Albert, 21 Santillane Ave., Coral Gables 34, Fla.
 Scott, Frederic R., 4600 Coventry Rd., Richmond 21, Va.
 Siekmann, Joyce, 2324 Ursuline Ave., New Orleans, La.
 Simonson, Walter E., 5104 26th Ave., So., Minneapolis 17, Minn.
 Slater, Craig E., R. D. 4, Slaterville Rd., Ithaca, N.Y.
 Sokol, Otto M., 341 Portola Ave., Palo Alto, Calif.
 Stephens, Robert F., 1050 W. Washington St., Charleston, W. Va.
 Tarrant, Ross, 1250 Chestnut Ave., Wilmette, Ill.
 Tortonese, Enrico, Musei di Zoologia e di Anatomia comparata, Via Accademia Albertina 17, Torino, Italy.
 Triplehorn, Charles A., 554 South Main St., Bluffton, Ohio.

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- Akademii Nauk, Biblioteka, ul. Dzerzhimskoyo 8, Tbilisi, U.S.S.R.
 Boston Univ., CLA Library, 725 Commonwealth Ave., Boston 15, Mass.
 N. V. Martinus Nijhoff, Lange Voorhout 9, The Hague, Holland.
 Gos Nauchn. Biblioteke, Minist. Vyssh. Obraz. pl. Nogina 2/5, Moscow, U.S.S.R.
 Montana State University, Library, Missoula, Mont.
 Parry Sound Forest District, District Biologist, Dept. of Lands and Forests, Parry Sound, Ont.
 Southern Illinois State Normal Univ., General Library, Carbondale, Ill.
 Southern Methodist Univ. Fondren Library, Dallas, Tex.
 Texas Ag. Exp. Sta., Administrative Dept., College Station, Tex.
 University of Alabama, Main Library, University, Ala.
 University Library, Stellenbosch, South Africa.
 University of Louisville, Library, Belknap Campus, Louisville 8, Ky.
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